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SECTION 230501: USE OF HVAC SYSTEMS DURING CONSTRUCTION

1. PART 1 - GENERAL

1.1 SUMMARY

1.1.1 Use of HVAC systems during construction.

1.2 RELATED SECTIONS

1.2.1 Section 01 51 00 - Temporary Utilities

1.3 USE OF SYSTEMS

1.3.1 Use of new and/or existing permanent heating and/or ventilating systems for supplying temporary heat or ventilation is permitted only under the following conditions:

1. Entire system is complete, pressure tested, cleaned, flushed out.
2. Specified water treatment system has been commissioned, water treatment is being continuously monitored.
3. Building has been closed in, areas to be heated/ventilated are clean and will not thereafter be subjected to dust-producing processes.
4. There is no possibility of damage from any cause.
5. Supply ventilation systems are protected by 60 % filters, which shall be inspected daily, changed every week or more frequently as required.
6. Return systems have approved filters over all openings, inlets, outlets.
7. All systems will be:
 - .1 Operated as per manufacturer's recommendations or instructions.
 - .2 Operated by Contractor.
 - .3 Monitored continuously by Contractor.
8. Warranties and guarantees are not thereby relaxed.
9. Regular preventive and all other manufacturers recommended maintenance routines are performed by Contractor at his own expense and under supervision of Owner.
10. Refurbish entire system before static completion; clean internally and externally, restore to "as- new" condition, and replace filters in air systems.

1.3.2 Filters specified in this section are over and above those specified in other sections of this project.

1.3.3 Exhaust systems are not included in any approvals for temporary heating ventilation.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION (NOT USED)

END OF SECTION

SECTION 230513: COMMON MOTOR REQUIREMENT**1. PART 1 General****1.1 SUMMARY****1.1.1 Section Includes:**

1. Electrical motors, drives and guards for mechanical equipment and systems.
2. Supplier and installer responsibility indicated in Motor, Control and Equipment Schedule on electrical drawings and related mechanical responsibility is indicated on Mechanical Equipment Schedule on mechanical drawings.
3. Control wiring and conduit specified in Division 26. Control wiring 50V or less for systems specified in Division 21, 22, 23 and 25 is by Division 25.

1.2 RELATED SECTIONS:

- 1.2.1 Section 01 33 00 - Submittal Procedures.
- 1.2.2 Section 01 74 21 - Construction/Demolition Waste Management and Disposal

1.3 REFERENCES

- 1.3.1 American Society of Heating, Refrigeration and Air-Conditioning Engineers (ASHRAE) ASHRAE 90.1, Energy Standard for Buildings Except Low-Rise Residential Buildings (IESNA cosponsored; ANSI approved; Continuous Maintenance Standard).
- 1.3.2 National Energy Code for Buildings (NECB).
- 1.3.3 National Electrical Manufacturers Association (NEMA).

1.4 SUBMITTALS

- 1.4.1 Submittals: in accordance with Section 01 33 00 - Submittal Procedures.
- 1.4.2 Product Data:
 1. Submit manufacturer's printed product literature, specifications and datasheet in accordance with Section 01 33 00 - Submittal Procedures. Include product characteristics, performance criteria, and limitations.
Submit two copies of Workplace Hazardous Materials Information System (WHMIS) Safety Data Sheets (SDS) in accordance with Section 01 33 00 - Submittal Procedures.
 2. Shop Drawings: Submit drawings stamped and signed for approval by Owner.
 3. Quality Control: in accordance with Section 01 45 00 - Quality Control.
Certificates: submit certificates signed by manufacturer certifying that materials comply with specified performance characteristics and physical properties.
Instructions: submit manufacturer's installation instructions.
Owner will make available one (1) copy of systems supplier's installation instructions.
 4. Closeout Submittals
Provide maintenance data for motors, drives and guards for incorporation into manual specified in Section 01 78 00 - Closeout Submittals.

1.5 QUALITY ASSURANCE

- 1.5.2 Regulatory Requirements: work to be performed in compliance with Canadian Environmental Protection Act (CEPA), Canadian Environmental Assessment Agency (CEAA), Transportation of Dangerous Goods Act (TDGA) and applicable Provincial regulations.

1.6 DELIVERY, STORAGE, AND HANDLING**1.6.2 Packing, shipping, handling and unloading:**

1. Deliver, store and handle in accordance with Section 01 61 00 - Common Product Requirements.
2. Deliver, store and handle materials in accordance with manufacturer's written instructions.

1.6.3 Waste Management and Disposal:

Construction/Demolition Waste Management and Disposal: separate waste materials for reuse and recycling in accordance with Section 01 74 21 - Construction/Demolition Waste Management and Disposal.

PART 2 Products**2.1 GENERAL**

- 2.1.1 Motors to be premium efficiency, in accordance with local hydro company standards and the requirements of ASHRAE 90.1.

2.2 MOTORS

- 2.2.1 Provide motors for mechanical equipment as specified.
- 2.2.2 Motors under 1/2 HP : speed as indicated, continuous duty, built-in overload protection, resilient mount, single phase, 120 V, unless otherwise specified or indicated.
- 2.2.3 Motors 1/2 HP and larger: NEMA, Class B, 1.15 service factor, squirrel cage induction, premium efficiency, speed as indicated, continuous duty, enclosure as indicated, ball bearing, maximum temperature rise 40°C, 3 phase, 575 V, unless otherwise indicated, for inverted duty for variable frequency drives.

2.3 TEMPORARY MOTORS

- 2.3.1 If delivery of specified motor will delay completion or commissioning work, install motor approved by Owner for temporary use. Work will only be accepted when specified motor is installed.

2.4 BELT DRIVES

- 2.4.1 Fit reinforced belts in sheave matched to drive. Multiple belts to be matched sets.
- 2.4.2 Use cast iron or steel sheaves secured to shafts with removable keys unless otherwise specified.
- 2.4.3 For motors under 10 HP: standard adjustable pitch drive sheaves, having plus or minus 10% range. Use mid-position of range for specified r/min.
- 2.4.4 For motors 10 HP and over: sheave with split tapered bushing and keyway having fixed pitch unless specifically required for item concerned. Provide sheave of correct size to suit balancing.
- 2.4.5 Correct size of sheave to be determined during commissioning.
- 2.4.6 Minimum drive rating: 1.5 times nameplate rating on motor. Keep overhung loads within manufacturer's design requirements on prime mover shafts.
- 2.4.7 Motor slide rail adjustment plates to allow for centre line adjustment.
- 2.4.8 Supply one set of spare belts for each set installed in accordance with Section 01 78 00 - Closeout Submittals.

2.5 DRIVE GUARDS

- 2.5.1 Provide guards for unprotected drives.
- 2.5.2 Guards for belt drives;
 - 1. Expanded metal screen welded to steel frame.
 - 2. Minimum 1.2 mm thick sheet metal tops and bottoms.
 - 3. 38 mm dia holes on both shaft centres for insertion of tachometer.
 - 4. Removable for servicing.
- 2.5.3 Provide means to permit lubrication and use of test instruments with guards in place.
- 2.5.4 Install belt guards to allow movement of motors for adjusting belt tension.
- 2.5.5 Guard for flexible coupling:
 - 1. "U" shaped, minimum 1.6 mm thick galvanized mild steel.
 - 2. Securely fasten in place.
 - 3. Removable for servicing.
- 2.5.6 Unprotected fan inlets or outlets:
 - 1. Wire or expanded metal screen, galvanized, 19 mm mesh.
 - 2. Net free area of guard: not less than 80% of fan openings.
 - 3. Securely fasten in place.
 - 4. Removable for servicing.

PART 3 Execution

3.1 MANUFACTURER'S INSTRUCTIONS

- 3.1.1 Compliance: comply with manufacturer's written recommendations or specifications, including product technical bulletins, handling, storage and installation instructions, and datasheet.

3.2 INSTALLATION

- 3.2.1 Fasten securely in place.
- 3.2.2 Make removable for servicing, easily returned into, and positively in position.

3.3 FIELD QUALITY CONTROL

- 3.3.1 Site Tests: conduct following tests in accordance with Section 01 45 00 - Quality Control and submit report as described in PART 1 - SUBMITTALS.
 - 3.3.1.1.1 As specified in other sections of this specification.
- 3.3.2 Manufacturer's Field Services:
 - 3.3.2.1.1 Obtain written report from manufacturer verifying compliance of Work, in handling, installing, applying, protecting and cleaning of product and submit Manufacturer's Field Reports as described in PART 1 - SUBMITTALS.
 - 3.3.2.1.2 Provide manufacturer's field services consisting of product use recommendations and periodic site visits for inspection of product installation in accordance with manufacturer's instructions.
 - 3.3.2.1.3 Schedule site visits, to review Work, as directed in PART 1 - QUALITY ASSURANCE.

3.4 CLEANING

- 3.4.1 Proceed in accordance with Section 01 74 00 - Cleaning.
- 3.4.2 Upon completion and verification of performance of installation, remove surplus materials, excess materials, rubbish, tools and equipment.

END OF SECTION

SECTION 230515: COMMON INSTALLATION REQUIREMENT OF PIPE**1. PART 1 GENERAL****1.1 RELATED SECTIONS**

- 1.1.1 Section 01 74 00 – Cleaning.
- 1.1.2 Section 01 74 21 – Construction / Demolition Waste Management and Disposal
- 1.1.3 Section 07 84 00 – Fire stopping.
- 1.1.4 Section 23 08 02 – Cleaning and Start-up of Mechanical Piping Systems.

1.2 WASTE MANAGEMENT AND DISPOSAL

- 1.2.1 Separate and recycle waste materials in accordance with Section 01 74 21 - Construction/Demolition Waste Management and Disposal.
- 1.2.2 Remove from site and dispose of packaging materials at appropriate recycling facilities.
- 1.2.3 Collect and separate for disposal, paper, plastic, polystyrene, corrugated cardboard packaging material in appropriate on-site bins for recycling in accordance with Waste Management Plan.
- 1.2.4 Divert unused metal materials from landfill to metal recycling facility approved by Owner.

1.3 QUALITY ASSURANCE

- 1.3.1 Installers to be certified to journey person.

PART 2 Products (NOT used)**2. PART 3 Execution****2.1 CONNECTIONS TO EQUIPMENT**

- 2.1.1 In accordance with manufacturer's instructions unless otherwise indicated.
- 2.1.2 Use valves and either unions or flanges for isolation and ease of maintenance and assembly.
 - 2.1.2.1.1 Unions are not required in installations using grooved mechanical couplings (The couplings shall serve as unions).
- 2.1.3 Use double swing joints when equipment mounted on vibration isolation and when piping subject to movement.
- 2.1.4 The flexible type grooved joint couplings may be used in lieu of a flexible connector at equipment connections for vibration attenuation and stress relief. Couplings shall be placed in close proximity to the source of the vibration, as per manufacturer's recommendations.

2.2 CLEARANCES

- 2.2.1 Provide clearance around systems, equipment and components for observation of operation, inspection, servicing, maintenance and as recommended by manufacturer.
- 2.2.2 Provide space for disassembly, removal of equipment and components as recommended by manufacturer or as indicated (whichever is greater) without interrupting operation of other system, equipment, and components.

2.3 DRAINS

- 2.3.1 Install piping with grade in direction of flow except as indicated.
- 2.3.2 Install drain valve at low points in piping systems, at equipment and at section isolating valves.
- 2.3.3 Pipe each drain valve discharge separately to above floor drain. Discharge to be visible.

- 2.3.4 Drain valves: NPS 3/4 gate or globe valves unless indicated otherwise, with hose end male thread, cap and chain.
- 2.4 AIR VENTS
 - 2.4.1 Install automatic air vents at high points in piping systems.
 - 2.4.2 Install isolating valve at each automatic air valve.
 - 2.4.3 Install drain piping to approved location and terminate where discharge is visible.
- 2.5 DIELECTRIC WATERWAY FITTINGS AND COUPLINGS
 - 2.5.1 General: Compatible with system, to suit pressure rating of system.
 - 2.5.2 Locations: Where dissimilar metals are joined.
 - 2.5.3 NPS 2 and under: Isolating waterway fittings, unions or bronze valves.
Waterway fittings shall be complete with thermoplastic liner.
 - 2.5.4 Over NPS 2: Isolating waterway fittings and flanges.
Waterway fittings shall be complete with thermoplastic liner.
- 2.6 PIPEWORK INSTALLATION
 - 2.6.1 Installation by certified journeyman.
 - 2.6.2 Screwed fittings jointed with Teflon tape or pipe dope as recommended by manufacturer.
 - 2.6.3 Grooved joint couplings and fittings shall be installed in accordance with the manufacturer's written installation instructions.
 - 2.6.3.1.1 Gaskets shall be verified as suitable for the intended service prior to installation. Gaskets shall be molded and produced by the coupling manufacturer.
 - 2.6.3.1.2 The grooved coupling manufacturer's factory trained representative shall provide on-site training for contractor's field personnel in the use of grooving tools, application of groove, and installation of grooved joint products. The manufacturer's representative shall periodically visit the jobsite and review installation. Contractor shall remove and replace any joints deemed improperly installed.
 - 2.6.4 Push-to-connect piping: Prepare copper tube and install in strict accordance with installation instructions. Pipe ends shall be cleaned, free from indentations, projections, burrs and foreign matter. Use a tube preparation tool as supplied by the manufacturer to clean and make installation mark. Push copper tube into fittings to installation depth mark, per installation instructions. Keep fittings free of dirt and oil.
 - 2.6.5 Protect openings against entry of foreign material.
 - 2.6.6 Install to isolate equipment and allow removal without interrupting operation of other equipment or systems.
 - 2.6.7 Assemble piping using fittings manufactured to ANSI standards.
 - 2.6.8 Saddle type branch fittings may be used on mains if branch line is no larger than half the size of main.
 - 2.6.8.1.1 Hole saw (or drill) and ream main to maintain full inside diameter of branch line prior to welding saddle.
 - 2.6.9 Install exposed piping, equipment, rectangular cleanouts and similar items parallel or perpendicular to building lines.
 - 2.6.10 Install concealed pipework to minimize furring space, maximize headroom, and conserve space.
 - 2.6.11 Slope piping, except where indicated, in direction of flow for positive drainage and venting.
 - 2.6.12 Install, except where indicated, to permit separate thermal insulation of each pipe.

- 2.6.13 Group piping wherever possible and as indicated.
- 2.6.14 Ream pipes, remove scale and other foreign material before assembly.
- 2.6.15 Use eccentric reducers at pipe size changes to ensure positive drainage and venting.
- 2.6.16 Provide for thermal expansion as indicated.
- 2.6.17 Valves:
 - 2.6.17.1.1 Install in accessible locations.
 - 2.6.17.1.2 Remove interior parts before soldering.
 - 2.6.17.1.3 Install with stems above horizontal position unless otherwise indicated.
 - 2.6.17.1.4 Valves accessible for maintenance without removing adjacent piping.
 - 2.6.17.1.5 Install globe valves in bypass around control valves.
 - 2.6.17.1.6 Use ball or butterfly valves at branch take-offs for isolating purposes except where otherwise specified.
 - 2.6.17.1.7 Install butterfly valves on chilled water and related condenser water systems only.
 - 2.6.17.1.8 Install butterfly valves between weld neck flanges to ensure full compression of liner.
 - 2.6.17.1.9 Install ball valves for glycol service.
 - 2.6.17.1.10 Use chain operators on valves NPS 2-1/2 and larger where installed more than 2400 mm above floor in Mechanical Rooms.
- 2.6.18 Check Valves:
 - 2.6.18.1.1 Install silent check valves on discharge of pumps and in vertical pipes with downward flow and elsewhere as indicated.
 - 2.6.18.1.2 Install swing check valves in horizontal lines on discharge of pumps and elsewhere as indicated.
- 2.7 SLEEVES
 - 2.7.1 General: Install where pipes pass through masonry, concrete structures, fire rated assemblies, and elsewhere as indicated.
 - 2.7.2 Material: Schedule 40 black steel pipe.
 - 2.7.3 Construction: Foundation walls and where sleeves extend above finished floors to have annular fins continuously welded on at mid-point.
 - 2.7.4 Sizes: 6 mm minimum clearance between sleeve and uninsulated pipe or between sleeve and insulation.
 - 2.7.5 Installation:
 - 2.7.5.1.1 Concrete, masonry walls, and concrete floors on grade: Terminate flush with finished surface.
 - 2.7.5.1.2 Other floors: Terminate 25 mm above finished floor.
 - 2.7.5.1.3 Before installation, paint exposed exterior surfaces with heavy application of zinc-rich paint.
 - 2.7.6 Sealing:
 - 2.7.6.1.1 Foundation walls and below grade floors: Fire retardant, waterproof non-hardening mastic.
 - 2.7.6.1.2 Elsewhere: Provide space for fire stopping. Maintain fire rating integrity.
 - 2.7.6.1.3 Sleeves installed for future use: Fill with lime plaster or other easily removable filler.
 - 2.7.6.1.4 Ensure no contact between copper pipe or tube and sleeve.

2.8 ESCUTCHEONS

- 2.8.1 Install on pipes passing through walls, partitions, floors, and ceilings in finished areas.
- 2.8.2 Construction: One piece type with set screws. Chrome or nickel plated brass or type 302 stainless steel.
- 2.8.3 Sizes: Outside diameter to cover opening or sleeve. Inside diameter to fit around pipe or outside of insulation if so provided.

2.9 PREPARATION FOR FIRESTOPPING

- 2.9.1 Material and installation within annular space between pipes, ducts, insulation and adjacent fire separation to Section 07 84 00 - Fire stopping.
- 2.9.2 Uninsulated unheated pipes not subject to movement: No special preparation.
- 2.9.3 Uninsulated heated pipes subject to movement: Wrap with non-combustible smooth material to permit pipe movement without damaging fire stopping material or installation, or install per manufacturer's recommendation as specified within the associated approval.
- 2.9.4 Insulated pipes and ducts: Ensure integrity of insulation and vapour barriers.

2.10 FLUSHING OUT OF PIPING SYSTEMS

- 2.10.1 In accordance with Section 23 08 02 - Cleaning and Start-up of Mechanical Piping Systems.
- 2.10.2 Before start-up, clean interior of piping systems in accordance with requirements of Section 01 74 00 - Cleaning supplemented as specified in relevant sections of other Divisions.
- 2.10.3 Preparatory to acceptance, clean and refurbish equipment and leave in operating condition, including replacement of filters in piping systems.

2.11 PRESSURE TESTING OF EQUIPMENT AND PIPEWORK

- 2.11.1 Advise Owner, 48 hours minimum prior to performance of pressure tests.
- 2.11.2 Pipework: Test as specified in relevant sections of other sections or Divisions.
- 2.11.3 Maintain specified test pressure without loss for four (4) hours minimum unless specified for longer period of time in relevant sections of other Divisions.
- 2.11.4 Prior to tests, isolate equipment and other parts which are not designed to withstand test pressure or media.
- 2.11.5 Conduct tests in presence of Owner. Work to be carried out in off hours after 5 p.m., weekends or holidays.
- 2.11.6 Pay costs for repairs or replacement, retesting, and making good. Owner to determine whether repair or replacement is appropriate.

Insulate or conceal work only after approval and certification of tests by Owner.

2.12 EXISTING SYSTEMS

- 2.12.1 Connect into existing piping systems at times approved by Owner. Work to be carried out off hours after 5 p.m., weekends or holidays.
- 2.12.2 Request written approval ten (10) working days minimum, prior to commencement of work.
- 2.12.3 Be responsible for damage to existing plant by this work.
- 2.12.4 Ensure daily clean-up of existing areas.

END OF SECTION

SECTION 230516: EXPANSION FITTINGS AND LOOPS OF PIPE**1. PART 1 GENERAL****1.1 SECTION INCLUDES**

- 1.1.1 Materials and installation for flexible connections, expansion joints, anchors and guides for building services piping.

1.2 RELATED SECTIONS

- 1.2.1 Section 01 33 00 - Submittal Procedures.
- 1.2.2 Section 01 74 21 - Construction/Demolition Waste Management And Disposal.
- 1.2.3 Section 01 78 00 - Closeout Submittals.
- 1.2.4 Section 03 20 00 - Concrete Reinforcing.
- 1.2.5 Section 03 30 00 - Cast-in-Place Concrete.
- 1.2.6 Section 03 30 00.01 - Cast-in-Place - Short Form.
- 1.2.7 Section 23 08 02 - Cleaning and Start-up of Mechanical Piping Systems.
- 1.2.8 Section 23 08 01 - Performance Verification Mechanical Piping Systems.

1.3 REFERENCES

- 1.3.1 American Society for Testing and Materials International, (ASTM).
 - 1.3.1.1.1 ASTM A 53/A53M, Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless.
 - 1.3.1.1.2 ASTM A 105/A105M, Standard Specification for Carbon Steel Forgings, for Piping Applications.

1.4 SUBMITTALS

- 1.4.1 Submittals in accordance with Section 01 33 00 - Submittal Procedures.
- 1.4.2 Submit product data and indicate for items as applicable:
 - 1.4.2.1.1 Manufacturer, model number, line contents, pressure and temperature rating.
 - 1.4.2.1.2 Movement handled, axial, lateral, angular and the amounts of each.
 - 1.4.2.1.3 Nominal size and dimensions including details of construction and assembly.
- 1.4.3 Submit maintenance data in accordance with Section 01 78 00 - Closeout Submittals.
- 1.4.4 Data to include:
 - 1.4.4.1.1 Servicing requirements, including special requirements, stuffing box packing, lubrication and recommended procedures.

1.5 WASTE MANAGEMENT AND DISPOSAL

- 1.5.1 Separate waste materials for reuse and recycling in accordance with Section 01 74 21 - Construction/Demolition Waste Management and Disposal.
- 1.5.2 Remove from site and dispose of packaging materials at appropriate recycling facilities.
- 1.5.3 Collect, separate and place in designated containers for reuse and recycling, paper, plastic, polystyrene, corrugated cardboard packaging, steel, metal, in accordance with Waste Management Plan.
- 1.5.4 Unused sealant materials must not be disposed of into sewer system, into streams, lakes, onto ground or in other location where it will pose health or environmental hazard.
- 1.5.5 Fold up metal banding, flatten and place in designated area for recycling.

2. PART 2 PRODUCTS

2.1 SLIP TYPE EXPANSION JOINTS

- 2.1.1 Application: for axial pipe movement, as indicated.
- 2.1.2 Repacking: under full line pressure.
- 2.1.3 Body and packing housings: Class 150, 1MPa or Class 300, 2MPa carbon steel pipe to ASTM A53/A53M, Grade B. Wall thickness to match pipe with raised face slip-on or weld neck flanges to match pipe.
- 2.1.4 Slip or traverse sleeves: carbon steel pipe to ASTM A53/A53M, Grade B, hard chrome plated.
- 2.1.5 Anchor base: construction steel, welded to body.
- 2.1.6 Guides (internal and external): embody into packing housing with concentric alignment of slip or traverse sleeve with packing housing.
- 2.1.7 Extension limit stop: stainless steel, to prevent over-extension with accessible and removable pins.
- 2.1.8 Packing rings: 6.0 minimum, PTFE or graphite impregnated non-asbestos.
- 2.1.9 Thermal plastic packing: PTFE or graphite impregnated non-asbestos slug supplied loose.
- 2.1.10 Lubricating fittings: pet cocks with grease nipple.
- 2.1.11 Plunger body and plunger:
 - 2.1.11.1 Plunger body: heavy wall carbon steel welded to body.
 - 2.1.11.2 Plunger: carbon steel with hex head for use with socket wrench.
- 2.1.12 Lubricant: to manufacturer's recommendations.
- 2.1.13 Lubricant gun: complete with hose assembly.
- 2.1.14 Drip connection: 20 MPa forged steel to ASTM A 105/A105M. Include half coupling with drain plug.

2.2 BELLOWS TYPE EXPANSION JOINTS

- 2.2.1 For axial, lateral or angular movements, as indicated.
- 2.2.2 Maximum operating pressure: same as pipe rating.
- 2.2.3 Maximum operating temperature: same as pipe rating.
- 2.2.4 Type A: controlled free flexing, factory tested to 1 ½ times maximum working pressure. Furnish test certificates.
- 2.2.5 Type B: externally pressurized, constant volume, pressure balanced, designed to eliminate pressure thrust, factory tested to 1 ½ times maximum working pressure. Furnish test certificates.
- 2.2.6 Bellows:
 - 2.2.6.1.1 Multiple bellows, hydraulically formed, single or two ply, austenitic stainless steel, monel, or inconel for specified fluid, pressure and temperature, water treatment and pipeline cleaning procedures.
- 2.2.7 Reinforcing or control rings: 2piece nickel iron.
- 2.2.8 Ends:
 - 2.2.8.1.1 Raised face, slip-on or weld neck flanges to match pipe.
- 2.2.9 Liner:
 - 2.2.9.1.1 Austenitic stainless steel in direction of flow.
- 2.2.10 Shroud:
 - 2.2.10.1.1 Carbon steel, painted.

2.3 FLEXIBLE CONNECTION

- 2.3.1 Application: to suit motion as indicated.
- 2.3.2 Minimum length in accordance with manufacturer's recommendations to suit offset
- 2.3.3 Inner hose: bronze or stainless steel corrugated.

- 2.3.4 Braided wire mesh bronze or stainless steel outer jacket.
- 2.3.5 Diameter and type of end connection: threaded or flanged, same as pipe joint for the pipe size.
- 2.3.6 Operating conditions:
 - 2.3.6.1.1 Working pressure: 1034 kPa.
 - 2.3.6.1.2 Working temperature: to match system requirements.
 - 2.3.6.1.3 To match system requirements.
- 2.4 ANCHORS AND GUIDES
 - 2.4.1 Anchors:
 - 2.4.1.1.1 Provide as indicated.
 - 2.4.1.1.2 Concrete: to Section 03 30 00 - Cast-in-Place.
 - 2.4.1.1.3 Reinforcement: to Section 03 20 00 - Concrete Reinforcing.
 - 2.4.2 Alignment guides:
 - 2.4.2.1.1 Provide as indicated.
 - 2.4.2.1.2 To accommodate specified thickness of insulation.
 - 2.4.2.1.3 Vapour barriers, jackets to remain uninterrupted.
- 3. PART 3 EXECUTION
 - 3.1 INSTALLATION
 - 3.1.1 Install expansion joints with cold setting. Make record of cold settings.
 - 3.1.2 Install expansion joints and flexible connections in accordance with manufacturer's instructions.
 - 3.1.3 Install pipe anchors and guides as indicated. Anchors to withstand 150 % of axial thrust.
 - 3.2 4.1CLEANING AND START-UP
 - 3.2.1 In accordance with Section 23 08 02 - Cleaning and Start-up of Mechanical Piping Systems.
 - 3.3 4.1PERFORMANCE VERIFICATION
 - 3.3.1 In accordance with Section 23 08 01 - Performance Verification: Mechanical Piping Systems.

END OF SECTION

SECTION 230529: HANGERS AND SUPPORTS FOR HVAC PIPING AND EQUIPMENT

1. PART 1 General

1.1 SUMMARY

1.1.1 Section includes:

- 1.1.1.1 Concrete housekeeping pads, hangers and supports for mechanical piping, ducting and equipment.

1.2 Related Sections

- 1.2.1 Section 01 33 00 - Submittal Procedures.
- 1.2.2 Section 01 74 21 - Construction/Demolition Waste Management and Disposal
- 1.2.3 Section 03 30 00 - Cast-in-Place Concrete.
- 1.2.4 Section 05 12 23 - Structural Steel for Buildings.
- 1.2.5 Section 05 50 00 - Metal Fabrications.

1.3 REFERENCES

- 1.3.1 American National Standards Institute/ American Society of Mechanical Engineers (ANSI/ASME)
 - 1.3.1.1 ANSI/ASME B31.1, Power Piping, (SI Edition).
- 1.3.2 American Society for Testing and Materials (ASTM)
 - 1.3.2.1 ASTM A125, Specification for Steel Springs, Helical, Heat-Treated.
 - 1.3.2.2 ASTM A307, Specification for Carbon Steel Bolts and Studs, 60,000 PSI Tensile Strength.
 - 1.3.2.3 ASTM A563, Specification for Carbon and Alloy Steel Nuts.
- 1.3.3 Factory Mutual (FM)
- 1.3.4 Manufacturer's Standardization Society of the Valves and Fittings Industry (MSS)
 - 1.3.4.1 MSS SP-58, Pipe Hangers and Supports - Materials, Design and Manufacture.
 - 1.3.4.2 ANSI/MSS SP-69, Pipe Hangers and Supports - Selection and Application.
 - 1.3.4.3 MSS SP-89, Pipe Hangers and Supports - Fabrication and Installation Practices.
- 1.3.5 Underwriter's Laboratories of Canada (ULC)

1.4 SYSTEM DESCRIPTION

1.4.1 Design Requirements

- 1.4.1.1 Construct pipe hanger and support to manufacturer's recommendations utilizing manufacturer's regular production components, parts and assemblies.
- 1.4.1.2 Base maximum load ratings on allowable stresses prescribed by MSS SP58 or ASME B31.1.
- 1.4.1.3 Ensure that supports, guides, anchors do not transmit excessive quantities of heat to building structure.
- 1.4.1.4 Design hangers and supports to support systems under all conditions of operation, allow free expansion and contraction, prevent excessive stresses from being introduced into pipework or connected equipment.
- 1.4.1.5 Provide for vertical adjustments after erection and during commissioning. Amount of adjustment to be in accordance with MSS SP58.

1.4.2 Performance Requirements

- 1.4.2.1 Design supports, platforms, catwalks, hangers, to withstand seismic events for location as per the National Building Code

1.5 SUBMITTALS

- 1.5.1 Submittals: in accordance with Section 01 33 00 - Submittal Procedures.
- 1.5.2 Shop drawings: submit drawings stamped and signed for approval by Owner.
- 1.5.3 Submit shop drawings and product data for following items:
 - 1.5.3.1 Bases, hangers and supports.
 - 1.5.3.2 Connections to equipment and structure.
 - 1.5.3.3 Structural assemblies.
- 1.5.4 Quality assurance submittals: submit following in accordance with Section 01 33 00 - Submittal Procedures.
 - 1.5.4.1 Certificates: submit certificates signed by manufacturer certifying that materials comply with specified performance characteristics and physical properties.
 - 1.5.4.2 Instructions: submit manufacturer's installation instructions.
- 1.5.4.2.1 Owner will make available one (1) copy of systems supplier's installation instructions.
- 1.5.5 Closeout Submittals:
 - 1.5.5.1 Provide maintenance data for incorporation into manual specified in Section 01 78 00 - Closeout Submittals

1.6 QUALITY ASSURANCE

- 1.6.1 Health and Safety:
 - 1.6.1.1 Do construction occupational health and safety in accordance with Safety Requirements.

1.7 DELIVERY, STORAGE, AND HANDLING

- 1.7.1 Packing, shipping, handling and unloading:
 - 1.7.1.1 Deliver, store and handle in accordance with Section 01 61 00 - Common Product Requirements.
 - 1.7.1.2 Deliver, store and handle materials in accordance with manufacturer's written instructions.
- 1.7.2 Waste Management and Disposal:
 - 1.7.2.1 Construction/Demolition Waste Management and Disposal: separate waste materials for reuse and recycling in accordance with Section 01 74 21 - Construction/Demolition Waste Management and Disposal.

2. PART 2 PRODUCTS**2.1 GENERAL**

- 2.1.1 Fabricate hangers, supports and sway braces in accordance with ANSI B31.1 and MSS SP-58 and SP-89.
- 2.1.2 Use components for intended design purpose only. Do not use for rigging or erection purposes.

2.2 PIPE HANGERS

- 2.2.1 Finishes:
 - 2.2.1.1 Pipe hangers and supports: galvanized painted with zinc-rich paint after manufacture.
 - 2.2.1.2 Use electro-plating galvanizing process or hot dipped galvanizing process.
 - 2.2.1.3 Ensure steel hangers in contact with copper piping are copper plated or epoxy coated.
- 2.2.2 Upper attachment structural: Suspension from lower flange of I-Beam.

- 2.2.2.1 Cold piping NPS 2 maximum: malleable iron C-clamp with hardened steel cup point setscrew, locknut and carbon steel retaining clip.
- 2.2.2.1.1 Rod: 9 mm UL listed, 13 mm FM approved.
- 2.2.2.2 Cold piping NPS 2 1/2 or greater, hot piping: Malleable iron beam clamp, eye rod, jaws and extension with carbon steel retaining clip, tie rod, nuts and washers, UL listed, FM approved where required to MSS-SP58 and MSS-SP69.
- 2.2.3 Upper attachment structural: Suspension from upper flange of I-Beam.
 - 2.2.3.1 Cold piping NPS 2 maximum: Ductile iron top-of-beam C-clamp with hardened steel cup point setscrew, locknut and carbon steel retaining clip, UL listed FM approved where required to MSS SP69.
 - 2.2.3.2 Cold piping NPS 2 1/2 or greater, all hot piping: Malleable iron top-of-beam jaw-clamp with hooked rod, spring washer, plain washer and nut UL listed, FM approved where required.
- 2.2.4 Upper attachment to concrete.
 - 2.2.4.1 Ceiling: Carbon steel welded eye rod, clevis plate, clevis pin and cotters with weldless forged steel eye nut. Ensure eye 6 mm minimum greater than rod diameter.
 - 2.2.4.2 Concrete inserts: wedge shaped body with knockout protector plate UL listed FM approved where required to MSS SP-69.
- 2.2.5 Shop and field-fabricated assemblies.
 - 2.2.5.1 Trapeze hanger assemblies: MSS SP-89.
 - 2.2.5.2 Steel brackets: MSS SP-89.
 - 2.2.5.3 Sway braces for seismic restraint systems: to MSS SP-89.
- 2.2.6 Hanger rods: threaded rod material to MSS SP-58.
 - 2.2.6.1 Ensure that hanger rods are subject to tensile loading only.
 - 2.2.6.2 Provide linkages where lateral or axial movement of pipework is anticipated.
 - 2.2.6.3 Do not use 22 mm or 28 mm rod.
- 2.2.7 Pipe attachments: material to MSS SP-58.
 - 2.2.7.1 Attachments for steel piping: carbon steel galvanized.
 - 2.2.7.2 Attachments for copper piping: copper plated black steel.
 - 2.2.7.3 Use insulation saddles for hot pipework.
 - 2.2.7.4 Oversize pipe hangers and supports for insulated pipes.
- 2.2.8 Adjustable clevis: material to MSS SP-69, UL listed FM approved, where required clevis bolt with nipple spacer and vertical adjustment nuts above and below clevis.
 - 2.2.8.1 Ensure "U" has hole in bottom for rivetting to insulation shields.
- 2.2.9 Yoke style pipe roll: carbon steel yoke, rod and nuts with cast iron roll, to MSS SP-69.
- 2.2.10 U-bolts: carbon steel to MSS SP-69 with 2 nuts at each end to ASTM A563.
 - 2.2.10.1 Finishes for steel pipework: galvanized.
 - 2.2.10.2 Finishes for copper, glass, brass or aluminum pipework: black with formed portion plastic coated or epoxy coated.
- 2.2.11 Pipe rollers: cast iron roll and roll stand with carbon steel rod to MSS SP-69.

2.3 RISER CLAMPS

- 2.3.1 Steel or cast iron pipe: galvanized black carbon steel to MSS SP-58, type 42, UL listed FM approved where required.
- 2.3.2 Copper pipe: carbon steel copper plated to MSS SP-58, type 42.
- 2.3.3 Bolts: to ASTM A307.
- 2.3.4 Nuts: to ASTM A563.

2.4 INSULATION PROTECTION SHIELDS**2.4.1 Insulated cold piping:**

2.4.1.1 64 kg/m³ density insulation plus insulation protection shield to: MSS SP-69, galvanized sheet carbon steel. Length designed for maximum 3.0 m span.

2.4.2 Insulated hot piping:

2.4.2.1 Curved plate 300 mm long, with edges turned up, welded-in centre plate for pipe sizes NPS 12 and over, carbon steel to comply with MSS SP-69.

2.5 CONSTANT SUPPORT SPRING HANGERS

2.5.1 Springs: alloy steel to ASTM A125, shot peened, magnetic particle inspected, with +/-5% spring rate tolerance, tested for free height, spring rate, and loaded height and provided with Certified Mill Test Report (CMTR).

2.5.2 Load adjustability: 10 % minimum adjustability each side of calibrated load. Adjustment without special tools. Adjustments not to affect travel capabilities.

2.5.3 Provide upper and lower factory set travel stops.

2.5.4 Provide load adjustment scale for field adjustments.

2.5.5 Total travel to be actual travel + 20%. Difference between total travel and actual travel 25 mm minimum.

2.5.6 Individually calibrated scales on each side of support calibrated prior to shipment, complete with calibration record.

2.6 VARIABLE SUPPORT SPRING HANGERS

2.6.1 Vertical movement: 13 mm minimum, 50 mm maximum, use single spring pre-compressed variable spring hangers.

2.6.2 Vertical movement greater than 50 mm: use double spring pre-compressed variable spring hanger with 2 springs in series in single casing.

2.6.3 Variable spring hanger to be complete with factory calibrated travel stops. Provide certificate of calibration for each hanger.

2.6.4 Steel alloy springs: to ASTM A125, shot peened, magnetic particle inspected, with +/-5 % spring rate tolerance, tested for free height, spring rate, loaded height and provided with CMTR.

2.7 EQUIPMENT SUPPORTS

2.7.1 Fabricate equipment supports not provided by equipment manufacturer from structural grade steel meeting requirements of Section 05 12 23 - Structural Steel for Buildings. Submit calculations with shop drawings.

2.8 EQUIPMENT ANCHOR BOLTS AND TEMPLATES

2.8.1 Provide templates to ensure accurate location of anchor bolts.

2.9 PLATFORMS AND CATWALKS

2.9.1 To Section 05 50 00 - Metal Fabrication.

2.10 HOUSE-KEEPING PADS

2.10.1 For base-mounted equipment: Concrete, at least 100 mm high, 50 mm larger all around than equipment, and with chamfered edges.

2.10.2 Concrete: to Section 03 30 00 - Cast-in-place Concrete by Division 3.

2.11 OTHER EQUIPMENT SUPPORTS

2.11.1 From structural grade steel meeting requirements of Section 05 12 23 - Structural Steel for Buildings.

2.11.2 Submit structural calculations with shop drawings.

3. EXECUTION**3.1 MANUFACTURER'S INSTRUCTIONS**

- 3.1.1 Compliance: comply with manufacturer's written recommendations or specifications, including product technical bulletins, handling, storage and installation instructions, and datasheet.

3.2 INSTALLATION

- 3.2.1 Install in accordance with:
- 3.2.1.1 Manufacturer's instructions and recommendations.
- 3.2.2 Vibration Control Devices:
- 3.2.2.1 Install on piping systems at pumps, boilers, chillers, cooling towers, elsewhere as indicated.
- 3.2.3 Clamps on riser piping:
- 3.2.3.1 Support independent of connected horizontal pipework using riser clamps and riser clamp lugs welded to riser.
- 3.2.3.2 Bolt-tightening torques to be to industry standards.
- 3.2.3.3 Steel pipes: Install below coupling or shear lugs welded to pipe.
- 3.2.3.4 Cast iron pipes: Install below joint.
- 3.2.4 Clevis plates:
- 3.2.4.1 Attach to concrete with 4 minimum concrete inserts, one at each corner.
- 3.2.5 Provide supplementary structural steelwork where structural bearings do not exist or where concrete inserts are not in correct locations.
- 3.2.6 Use approved constant support type hangers where:
- 3.2.6.1 vertical movement of pipework is 13 mm or more,
- 3.2.6.2 Transfer of load to adjacent hangers or connected equipment is not permitted.
- 3.2.7 Use variable support spring hangers where:
- 3.2.7.1 Transfer of load to adjacent piping or to connected equipment is not critical.
- 3.2.7.2 Variation in supporting effect does not exceed 25 % of total load.

3.3 HANGER SPACING

- 3.3.1 Plumbing piping: most stringent requirements of Canadian Plumbing Code
- 3.3.2 Fire protection: to applicable fire code.
- 3.3.3 Gas and fuel oil piping: up to NPS 1/2: every 1.8 m.
- 3.3.4 Copper piping: up to NPS 1/2: every 1.5 m.
- 3.3.5 Hydronic, steam, condensate, rigid, and flexible joint roll groove pipe: in accordance with table below, but not less than one hanger at joints.

Maximum Pipe Size: NPS	Maximum Spacing: Steel	Maximum Spacing: Copper
up to 1-1/4	2.1 m	1.8 m
1-1/2	2.7 m	2.4 m
2	3.0 m	2.7 m
2-1/2	3.6 m	3.0 m
3	3.6 m	3.0 m
3-1/2	3.9 m	3.3 m
4	4.2 m	3.6 m
5	4.8 m	

Maximum Pipe Size: NPS	Maximum Spacing: Steel	Maximum Spacing: Copper
6	5.1 m	
8	5.7 m	
10	6.6 m	
12	6.9 m	

3.3.6 Within 300 mm of each elbow.

3.3.7 Pipework greater than NPS 12: to MSS SP69.

3.4 HANGER INSTALLATION

3.4.1 Install hanger so that rod is vertical under operating conditions.

3.4.2 Adjust hangers to equalize load.

3.4.3 Support from structural members. Where structural bearing does not exist or inserts are not in suitable locations, provide supplementary structural steel members, comprised of angel iron or c-channel.

3.5 HORIZONTAL MOVEMENT

3.5.1 Angularity of rod hanger resulting from horizontal movement of pipework from cold to hot position not to exceed 4 degrees from vertical.

3.5.2 Where horizontal pipe movement is less than 13 mm, offset pipe hanger and support so that rod hanger is vertical in the hot position.

3.6 FINAL ADJUSTMENT

3.6.1 Adjust hangers and supports:

3.6.1.1 Ensure that rod is vertical under operating conditions.

3.6.1.2 Equalize loads.

3.6.2 Adjustable clevis:

3.6.2.1 Tighten hanger load nut securely to ensure proper hanger performance.

3.6.2.2 Tighten upper nut after adjustment.

3.6.3 C-clamps:

3.6.3.1 Follow manufacturer's recommended written instructions and torque values when tightening C-clamps to bottom flange of beam.

3.6.4 Beam clamps:

3.6.4.1 Hammer jaw firmly against underside of beam.

END OF SECTION

SECTION 230553:

MECHANICAL IDENTIFICATION

1. PART 1 GENERAL

1.1 SUMMARY

1.1.1 Section Includes:

1.1.1.1 Materials and requirements for the identification of piping systems, duct work, valves and controllers, including the installation and location of identification systems.

1.1.1.2 Sustainable requirements for construction and verification.

1.2 RELATED SECTIONS

1.2.1 Section 01 33 00 - Submittal Procedures.

1.2.2 Section 01 74 21 - Construction/Demolition Waste Management and Disposal

1.2.3 Section 09 91 23 - Interior Painting.

1.3 REFERENCES

1.3.1 Canadian Gas Association (CGA)

1.3.1.1 CSA/CGA B149.1, Natural Gas and Propane Installation Code.

1.3.2 Canadian General Standards Board (CGSB)

1.3.2.1 CAN/CGSB-24.3, Identification of Piping Systems.

1.3.3 National Fire Protection Association (NFPA)

1.3.3.1 NFPA 13, Standard for the Installation of Sprinkler Systems.

1.3.3.2 NFPA 14, Standard for the Standpipe and Hose Systems.

1.4 SUBMITTALS

1.4.1 Product Data:

- 1.4.1.1 Submittals: in accordance with Section 01 33 00 - Submittal Procedures.
- 1.4.1.2 Product data to include paint colour chips, other products specified in this section.
- 1.4.1.3 Samples:
 - 1.4.1.3.1 Submit samples in accordance with Section 01 33 00 - Submittal Procedures.
 - 1.4.1.3.2 Samples to include nameplates, labels, tags, lists of proposed legends.
- 1.5 QUALITY ASSURANCE
 - 1.5.1 Quality assurance submittals: submit following in accordance with Section 01 33 00 - Submittal Procedures.
 - 1.5.2 Health and Safety:
 - 1.5.2.1 Do construction occupational health and safety in accordance with Safety Requirements.
- 1.6 DELIVERY, STORAGE, AND HANDLING
 - 1.6.1 Packing, shipping, handling and unloading:
 - 1.6.1.1 Deliver, store and handle in accordance with Section 01 61 00 - Common Product Requirements.
 - 1.6.1.2 Deliver, store and handle materials in accordance with manufacturer's written instructions.
 - 1.6.2 Waste Management and Disposal:
 - 1.6.2.1 Construction/Demolition Waste Management and Disposal: separate waste materials for reuse and recycling in accordance with Section 01 74 21 - Construction/Demolition Waste Management and Disposal.
 - 1.6.2.2 Dispose of unused paint coating material at official hazardous material collections site approved by Owner.
 - 1.6.2.3 Do not dispose of unused paint coating material into sewer system, into streams, lakes, onto ground or in locations where it will pose health or environmental hazard.
- 2. PART 2 PRODUCTS
 - 2.1 MANUFACTURER'S EQUIPMENT NAMEPLATES
 - 2.1.1 Metal or plastic laminate nameplate mechanically fastened to each piece of equipment by manufacturer.
 - 2.1.2 Lettering and numbers to be raised or recessed.
 - 2.1.3 Information to include, as appropriate:
 - 2.1.3.1 Equipment: Manufacturer's name, model, size, serial number, capacity.
 - 2.1.3.2 Motor: voltage, Hz, phase, power factor, duty, frame size.
 - 2.2 SYSTEM NAMEPLATES
 - 2.2.1 Colours:
 - 2.2.1.1 Hazardous: red letters, white background.
 - 2.2.1.2 Elsewhere: black letters, white background (except where required otherwise by applicable codes).
 - 2.2.2 Construction:
 - 2.2.2.1 3 mm thick laminated plastic or white anodized aluminum, matte finish, with square corners, letters accurately aligned and machine engraved into core.
 - 2.2.3 Sizes:
 - 2.2.3.1 Conform to following table:

Size # mm	Sizes (mm)	No. of Lines	Height of Letters (mm)
1	10 x 50	1	3
2	13 x 75	1	5
3	13 x 75	2	3
4	20 x 100	1	8
5	20 x 100	2	5
6	20 x 200	1	8
7	25 x 125	1	12
8	25 x 125	2	8
9	35 x 200	1	20

2.2.3.2 Use maximum of 25 letters/numbers per line.

2.2.4 Locations:

2.2.4.1 Terminal cabinets, control panels: Use size # 5.

2.2.4.2 Equipment in Mechanical Rooms: Use size # 9.

2.3 EXISTING IDENTIFICATION SYSTEMS

2.3.1 Apply existing identification system to new work.

2.3.2 Where existing identification system does not cover for new work, use identification system specified this section.

2.3.3 Before starting work, obtain written approval of identification system from Owner.

2.4 PIPING SYSTEMS GOVERNED BY CODES

2.4.1 Identification:

2.4.1.1 Natural gas: to CSA/CGA B149.1, authority having jurisdiction.

2.4.1.2 Propane gas: to CSA/CGA B149.1 authority having jurisdiction.

2.4.1.3 Sprinklers: to NFPA 13.

2.4.1.4 Standpipe and hose systems: to NFPA 14.

2.5 IDENTIFICATION OF PIPING SYSTEMS

2.5.1 Identify contents by background colour marking, pictogram (as necessary), legend; direction of flow by arrows. To CAN/CGSB 24.3 except where specified otherwise.

2.5.2 Pictograms:

2.5.2.1 Where required, to Workplace Hazardous Materials Information System (WHMIS) regulations.

2.5.3 Legend:

2.5.3.1 Block capitals to sizes and colours listed in CAN/CGSB 24.3.

2.5.4 Arrows showing direction of flow:

2.5.4.1 Outside diameter of pipe or insulation less than 75 mm: 100 mm long x 50 mm high.

2.5.4.2 Outside diameter of pipe or insulation 75 mm and greater: 150 mm long x 50 mm high.

2.5.4.3 Use double-headed arrows where flow is reversible.

2.5.5 Extent of background colour marking:

2.5.5.1 To full circumference of pipe or insulation.

2.5.5.2 Length to accommodate pictogram, full length of legend and arrows.

2.5.6 Materials for background colour marking, legend, arrows:

2.5.6.1 Pipes and tubing 20 mm and smaller: Waterproof and heat-resistant pressure sensitive plastic marker tags.

2.5.6.2 All other pipes: Pressure sensitive plastic-coated cloth or vinyl with protective over coating, waterproof contact adhesive undercoating,

suitable for ambient of 100%RH and continuous operating temperature of 150°C and intermittent temperature of 200°C.

2.5.7 Colours and Legends:

2.5.7.1 Where not listed, obtain direction from Owner.

2.5.7.2 Colors for legends, arrows, to following table:

Background colour	Legend, arrows
Yellow	BLACK
Green	WHITE
Red	WHITE

2.5.7.3 Background color marking and legends for piping systems:

Contents	Background colour marking	Legend
** Add design temperature		
++ Add design temperature and pressure		
Raw water	Green	RAW WATER
River water	Green	RIVER WATER
Sea water	Green	SEA WATER
City water	Green	CITY WATER
Treated water	Green	TREATED WATER
Brine	Green	BRINE
Condenser water supply	Green	COND. WTR. SUPPLY
Condenser water return	Green	COND. WTR. RETURN
Chilled water supply	Green	CH. WTR. SUPPLY
Chilled water return	Green	CH. WTR. RETURN
Hot water heating supply	Yellow	HEATING SUPPLY
Hot water heating return	Yellow	HEATING RETURN
High temp HW Htg. supply	Yellow	HTHW HTG. SUPPLY++
High temp HW Htg. return	Yellow	HTHW HTG. RETURN++
Make-up water	Yellow	MAKE-UP WTR
Boiler feed water	Yellow	BLR. FEED WTR
Steam ___kPa	Yellow	___kPa STEAM
Steam condensate (gravity)	Yellow	ST.COND.RET (GRAVITY)
Steam condensate (pumped)	Yellow	ST.COND.RET (PUMPED)
Safety valve vent	Yellow	STEAM VENT
Intermittent blow-off	Yellow	INT. BLOW-OFF
Continuous blow-off	Yellow	CONT. BLOW-OFF
Chilled drinking water	Green	CH. DRINK WTR
Drinking water return	Green	CH. DRINK WTR. CIRC
Domestic hot water supply	Green	DOM. HW SUPPLY

Contents	Background colour marking	Legend
** Add design temperature		
++ Add design temperature and pressure		
Dom. HWS recirculation	Green	DOM. HW CIRC
Domestic cold water supply	Green	DOM. CWS
Waste water	Green	WASTE WATER
Contaminated lab waste	Yellow	CONT. LAB WASTE
Acid waste	Yellow	ACID WASTE (add source)
Storm water	Green	STORM
Sanitary	Green	SAN
Plumbing vent	Green	SAN. VENT
Refrigeration suction	Yellow	REF. SUCTION
Refrigeration liquid	Yellow	REF. LIQUID
Refrigeration hot gas	Yellow	REF. HOT GAS
No. ___ fuel oil suction	Yellow	# ___ FUEL OIL
No. ___ fuel oil return	Yellow	# ___ FUEL OIL
Engine exhaust	Yellow	ENGINE EXHAUST
Lubricating oil	Yellow	LUB. OIL
Hydraulic oil	Yellow	HYDRAULIC OIL
Gasoline	Yellow	GASOLINE
Natural gas	to Codes	
Propane	to Codes	
Gas regulator vents	to Codes	
Distilled water	Green	DISTILL. WTR
Demineralized water	Green	DEMIN. WATER
Chlorine	Yellow	CHLORINE
Nitrogen	Yellow	NITROGEN
Oxygen	Yellow	OXYGEN
Compressed air (<700kPa)	Green	COMP. AIR ___ kPa
Compressed air (>700kPa)	Yellow	COMP. AIR ___ kPa
Vacuum	Green	VACUUM
Fire protection water	Red	FIRE PROT. WTR
Sprinklers	Red	SPRINKLERS
Carbon dioxide	Red	CO2
Instrument air	Green	INSTRUMENT AIR
Control air tubing	To Section 25 05 54 – EMCS: Identification	
Conduit for low voltage control wiring	To Section 25 05 54 – EMCS: Identification	

2.6 IDENTIFICATION DUCTWORK SYSTEMS

2.6.1 50 mm high stencilled letters and directional arrows 150 mm long x 50 mm high.

2.6.2 Colours: Black, or co-ordinated with base colour to ensure strong contrast.

2.6.3 Identify system: e.g. Supply AHU-1, Exhaust F-7.

2.7 VALVES, CONTROLLERS

2.7.1 Brass tags 12 mm diameter with stamped identification data filled with black paint.

2.7.2 Include flow diagrams for each system, of approved size, showing charts and schedules with identification of each tagged item, valve type, service, function, normal position, location of tagged item.

2.8 CONTROLS COMPONENTS IDENTIFICATION

2.8.1 Identify all systems, equipment, components, controls, and sensors with system nameplates specified in section 25 05 54 – EMCS: Identification. If no EMCS included in project, identification as per this section.

2.8.2 Inscriptions to include function and (where appropriate) fail-safe position, component ID name.

2.9 LANGUAGE

2.9.1 Identification to be in English.

3. PART 3 EXECUTION

3.1 MANUFACTURER'S INSTRUCTIONS

3.1.1 Compliance: comply with manufacturer's written recommendations or specifications, including product technical bulletins, handling, storage and installation instructions, and datasheet.

3.2 TIMING

3.2.1 Provide identification only after all painting specified in Section 09 91 23 - Interior Painting has been completed.

3.3 INSTALLATION

3.3.1 Perform work in accordance with CAN/CGSB-24.3 except as specified otherwise.

3.3.2 Provide ULC and/or CSA registration plates as required by respective agency.

3.4 NAMEPLATES

3.4.1 Locations:

3.4.1.1 In conspicuous location to facilitate easy reading and identification from operating floor.

3.4.2 Standoffs:

3.4.2.1 Provide for nameplates on hot and/or insulated surfaces.

3.4.3 Protection

3.4.3.1 Do not paint, insulate or cover in any way.

3.5 LOCATION OF IDENTIFICATION ON PIPING AND DUCTWORK SYSTEMS

3.5.1 On long straight runs in open areas in boiler rooms, equipment rooms, galleries, tunnels: At not more than 17 m intervals and more frequently if required to ensure that at least one is visible from any one viewpoint in operating areas and walking aisles.

3.5.2 Adjacent to each change in direction.

3.5.3 At least once in each small room through which piping or ductwork passes.

3.5.4 On both sides of visual obstruction or where run is difficult to follow.

3.5.5 On both sides of separations such as walls, floors, partitions.

3.5.6 Where system is installed in pipe chases, ceiling spaces, galleries, confined spaces, at entry and exit points, and at access openings.

3.5.7 At beginning and end points of each run and at each piece of equipment in run.

3.5.8 At point immediately upstream of major manually operated or automatically controlled valves, dampers, etc. Where this is not possible, place identification as close as possible, preferably on upstream side.

3.5.9 Identification to be easily and accurately readable from usual operating areas and from access points.

3.5.9.1 Position of identification to be approximately at right angles to most convenient line of sight, considering operating positions, lighting conditions, risk of physical damage or injury and reduced visibility over time due to dust and dirt.

3.6 VALVES, CONTROLLERS

3.6.1 Valves and operating controllers, except at plumbing fixtures, radiation, or where in plain sight of equipment they serve: Secure tags with non-ferrous chains or closed "S" hooks.

3.6.2 Install one copy of flow diagrams, valve schedules mounted in frame behind non-glare glass were directed by Owner. Provide one copy (reduced in size if required) in each operating and maintenance manual.

3.6.3 Number valves in each system consecutively.

3.7 CLEANING

3.7.1 Proceed in accordance with Section 01 74 00 - Cleaning.

3.7.2 Upon completion and verification of performance of installation, remove surplus materials, rubbish, tools and equipment.

END OF SECTION

SECTION 230593: TESTING, ADJUSTING AND BALANCING FOR HVAC**1. PART 1 GENERAL****1.1 SUMMARY**

- 1.1.1 TAB is used throughout this Section to describe the process, methods and requirements of testing, adjusting and balancing for HVAC.
- 1.1.2 TAB means to test, adjust and balance to perform in accordance with requirements of Contract Documents and to do other work as specified in this Section.

1.2 QUALIFICATIONS OF TAB PERSONNEL

- 1.2.1 Submit names of personnel certified to AABC, NEBB or SMACNA to perform TAB to Owner within 90 days of award of contract.
- 1.2.2 Provide documentation confirming qualifications, successful experience. TAB contractor shall have a minimum of 5 (five) years experience to AABC, NEBB or SMACNA.
- 1.2.3 TAB: performed in accordance with the requirements of standard under which TAB Firm's qualifications are approved:
 - 1.2.3.1 Associated Air Balance Council, (AABC) National Standards for Total System Balance, MN-1.
 - 1.2.3.2 National Environmental Balancing Bureau (NEBB) TABES, Procedural Standards for Testing, Adjusting, Balancing of Environmental Systems.
 - 1.2.3.3 Sheet Metal and Air Conditioning Contractors' National Association (SMACNA), HVAC TAB HVAC Systems - Testing, Adjusting and Balancing.
- 1.2.4 Recommendations and suggested practices contained in the TAB Standard: mandatory.
- 1.2.5 Use TAB Standard provisions, including checklists, and report forms to satisfy Contract requirements.
- 1.2.6 Use TAB standard for TAB, including qualifications for TAB Firm and Specialist and calibration of TAB instruments.
- 1.2.7 Where instrument manufacturer calibration recommendations are more stringent than those listed in the TAB standard, use manufacturer's recommendations.
- 1.2.8 TAB Standard quality assurance provisions such as performance guarantees form part of this contract.
 - 1.2.8.1 For systems or system components not covered in TAB standard, use TAB procedures developed by TAB Specialist.
 - 1.2.8.2 Where new procedures and requirements are applicable to Contract requirements have been published or adopted by body responsible for TAB Standard used (AABC, NEBB, or SMACNA), requirements and recommendations contained in these procedures and requirements are mandatory.

1.3 PURPOSE OF TAB

- 1.3.1 Test to verify proper and safe operation, determine actual point of performance, and evaluate qualitative and quantitative performance of equipment, systems and controls at design, average and low loads using actual or simulated loads.
- 1.3.2 Adjust and regulate equipment and systems so as to meet specified performance requirements and to achieve specified interaction with other related systems under normal and emergency loads and operating conditions.

- 1.3.3 Balance systems and equipment to regulate flow rates to match load requirements over full operating ranges.

1.4 EXCEPTIONS

- 1.4.1 TAB of systems and equipment regulated by codes, standards to be to satisfaction of authority having jurisdiction.

1.5 CO-ORDINATION

- 1.5.1 Schedule time required for TAB (including repairs, re-testing) into project construction and completion schedule so as to ensure completion before acceptance of project.
- 1.5.2 Do TAB of each system independently and subsequently, where interlocked with other systems, in unison with those systems.

1.6 PRE-TAB REVIEW

- 1.6.1 Review contract documents before project construction is started and confirm in writing to Owner adequacy of provisions for TAB and other aspects of design and installation pertinent to success of TAB.
- 1.6.2 Review specified standards and report to Owner in writing all proposed procedures which vary from standard.
- 1.6.3 During construction, co-ordinate location and installation of TAB devices, equipment, accessories, measurement ports and fittings.

1.7 START-UP

- 1.7.1 Follow start-up procedures as recommended by equipment manufacturer unless specified otherwise.
- 1.7.2 Follow special start-up procedures specified elsewhere in other Divisions.

1.8 OPERATION OF SYSTEMS DURING TAB

- 1.8.1 Operate systems for length of time required for TAB and as required by Owner for verification of TAB reports.

1.9 START OF TAB

- 1.9.1 Notify Owner seven (7) working days prior to start of TAB.
- 1.9.2 Start TAB when building is essentially completed, including:
 - 1.9.2.1 Installation of ceilings, doors, windows, other construction affecting TAB.
 - 1.9.2.2 Application of weather-stripping, sealing, caulking.
 - 1.9.2.3 All pressure, leakage, other tests specified elsewhere in other Divisions.
 - 1.9.2.4 All provisions for TAB installed and operational.
- 1.9.3 Start-up, verification for proper, normal and safe operation of mechanical and associated electrical and control systems affecting TAB including but not limited to:
 - 1.9.3.1 Proper thermal overload protection in place for electrical equipment.
 - 1.9.3.2 Air systems:
 - 1.9.3.2.1 Filters in place, clean.
 - 1.9.3.2.2 Duct systems clean.
 - 1.9.3.2.3 Ducts, air shafts, ceiling plenums are airtight to within specified tolerances.
 - 1.9.3.2.4 Correct fan rotation.
 - 1.9.3.2.5 Fire, smoke, volume control dampers installed and open.
 - 1.9.3.2.6 Coil fins combed, clean.
 - 1.9.3.2.7 Access doors, installed, closed.
 - 1.9.3.2.8 Outlets installed, volume control dampers open.
 - 1.9.3.3 Liquid systems:
 - 1.9.3.3.1 Flushed, filled, vented.
 - 1.9.3.3.2 Correct pump rotation.

- 1.9.3.3.3 Strainers in place, baskets clean.
- 1.9.3.3.4 Isolating and balancing valves installed, open.
- 1.9.3.3.5 Calibrated balancing valves installed, at factory settings.
- 1.9.3.3.6 Chemical treatment systems complete, operational.
- 1.10 APPLICATION TOLERANCES
 - 1.10.1 Do TAB to following tolerances of design values:
 - 1.10.1.1 Laboratory HVAC systems: plus 10%, minus 0%.
 - 1.10.1.2 Other HVAC systems: plus 5%, minus 5%.
 - 1.10.1.3 Hydronic systems: plus or minus 10 %.
 - 1.10.1.4 Refrigeration systems: plus or minus 10%.
- 1.11 ACCURACY TOLERANCES
 - 1.11.1 Measured values to be accurate to within plus or minus 2 % of actual values.
- 1.12 INSTRUMENTS
 - 1.12.1 Prior to TAB, submit to Owner list of instruments to be used together with serial numbers.
 - 1.12.2 Calibrate in accordance with requirements of most stringent of referenced standard for either applicable system or HVAC system.
 - 1.12.3 Calibrate within 3 (three) months of TAB. Provide certificate of calibration to Owner.
- 1.13 SUBMITTALS
 - 1.13.1 Submit, prior to commencement of TAB:
 - 1.13.2 Proposed methodology and procedures for performing TAB if different from referenced standard.
- 1.14 PRELIMINARY TAB REPORT
 - 1.14.1 Submit for checking and approval of Owner, prior to submission of formal TAB report, sample of rough TAB sheets. Include:
 - 1.14.1.1 Details of instruments used.
 - 1.14.1.2 Details of TAB procedures employed.
 - 1.14.1.3 Calculations procedures.
 - 1.14.1.4 Summaries.
- 1.15 TAB REPORT
 - 1.15.1 Format to be in accordance with referenced standard.
 - 1.15.2 TAB report to show results in SI units and to include:
 - 1.15.2.1 Project record drawings.
 - 1.15.2.2 System schematics.
 - 1.15.3 Submit 3 (three) copies of TAB Report to Owner for verification and approval, in English in D-ring binders, complete with index tabs.
- 1.16 VERIFICATION
 - 1.16.1 Reported results subject to verification by Owner.
 - 1.16.2 Provide manpower and instrumentation to verify up to 30% of reported results.
 - 1.16.3 Number and location of verified results to be at discretion of Owner.
 - 1.16.4 Bear costs to repeat TAB as required to satisfaction of Owner.
- 1.17 SETTINGS
 - 1.17.1 After TAB is completed to satisfaction of Owner, replace drive guards, close access doors, lock devices in set positions, and ensure sensors are at required settings.
 - 1.17.2 Permanently mark settings to allow restoration at any time during life of facility. Markings not to be eradicated or covered in any way.

- 1.18 COMPLETION OF TAB
 - 1.18.1 TAB to be considered complete when final TAB Report received and approved by Owner.
- 1.19 AIR SYSTEMS
 - 1.19.1 Standard: TAB to be to most stringent of this section or TAB standards of AABC or NEBB.
 - 1.19.2 Do TAB of systems, equipment, components, controls specified in other Divisions.
 - 1.19.3 Qualifications: personnel performing TAB to be qualified to standards of AABC or NEBB.
 - 1.19.4 Quality assurance: Perform TAB under direction of supervisor qualified to standards of AABC or NEBB.
 - 1.19.5 Measurements: to include, but not limited to, following as appropriate for systems, equipment, components, controls: air velocity, static pressure, flow rate, pressure drop (or loss), temperatures (dry bulb, wet bulb, dewpoint), duct cross-sectional area, RPM, electrical power, voltage, noise, vibration, amperage and volts for each stage of electrical heating coils.
 - 1.19.6 Locations of equipment measurements: To include, but not be limited to, following as appropriate:
 - 1.19.6.1 Inlet and outlet of dampers, filter, coil, humidifier, fan, other equipment causing changes in conditions.
 - 1.19.6.2 At controllers, controlled device.
 - 1.19.7 Locations of systems measurements to include, but not be limited to, following as appropriate: Main ducts, main branch, sub-branch, run-out (or grille, register or diffuser).
- 1.20 HYDRONIC SYSTEMS
 - 1.20.1 Definitions: for purposes of this section, to include low pressure hot water heating, chilled water, condenser water, glycol systems.
 - 1.20.2 Standard: TAB to be to most stringent of TAB standards of AABC or NEBB.
 - 1.20.3 Do TAB of systems, equipment, components, controls specified in other Divisions.
 - 1.20.4 Qualifications: personnel performing TAB to be qualified to standards of AABC or NEBB.
 - 1.20.5 Quality assurance: perform TAB under direction of supervisor qualified to standards of AABC or NEBB.
 - 1.20.6 Measurements: to include, but not limited to, following as appropriate for systems, equipment, components, controls: flow rate, static pressure, pressure drop (or loss), temperature, specific gravity, density, RPM, electrical power, voltage, noise, vibration.
 - 1.20.7 Locations of equipment measurement: to include, but not be limited to, following as appropriate:
 - 1.20.7.1 Inlet and outlet of heat exchangers (primary and secondary sides), boiler, chiller, coil, humidifier, cooling tower, condenser, pump, PRV, control valve, other equipment causing changes in conditions.
 - 1.20.7.2 At controllers, controlled device.
 - 1.20.8 Locations of systems measurements to include, but not be limited to, following as appropriate: supply and return of primary and secondary loops (main, main branch, branch, and sub-branch) of all hydronic systems, inlet connection of make-up water.
- 1.21 DOMESTIC WATER SYSTEMS
 - 1.21.1 Meet requirements as specified for hydronic systems.

- 1.21.2 Locations of equipment measurements: To include, but not be limited to, following as appropriate: inlet and outlet of heaters, tank, pump, circulator, at controllers, controlled device.
- 1.21.3 Locations of systems measurements to include, but not be limited to, following as appropriate: main, main branch, branch, sub-branch.
- 1.22 OTHER SYSTEMS
 - 1.22.1 Plumbing systems:
 - 1.22.1.1 Standard: National Plumbing Code.
 - 1.22.1.2 TAB procedures:
 - 1.22.1.2.1 Flush valves: adjust to suit project pressure conditions.
 - 1.22.1.2.2 Pressure booster systems: test for capacity and pressures under all conditions and at all times.
 - 1.22.1.2.3 Controlled flow roof drain systems: adjust weirs to suit actual roof conditions, slopes, areas drained.
 - 1.22.1.2.4 Pumped sanitary and storm water systems: test for proper operation at all possible flow rates. Refer to Section 32 32 13.13 – Packaged Sewage Lift, Wet Well Type.
 - 1.22.1.2.5 Pressure reducing station.
 - 1.22.2 Wet pipe sprinkler systems:
 - 1.22.2.1 Standard: NFPA.
 - 1.22.2.2 TAB procedures: Refer to NFPA 13 Sprinkler System.
 - 1.22.3 Refrigeration systems forming part of HVAC systems:
 - 1.22.3.1 Standard: CSA B52 – Mechanical Refrigeration Code.
 - 1.22.3.2 TAB procedures: Refer to Standard as follows:
 - 1.22.3.2.1 Suction Pressure and Temperature.
 - 1.22.3.2.2 Discharge Pressure and Temperature.
 - 1.22.3.2.3 Suction Superheat
 - 1.22.3.2.4 Evaporation Pressure and Temperature.
 - 1.22.4 Chemical treatment systems:
 - 1.22.4.1 Standard: Section 23 25 00 – HVAC Water Treatment.
 - 1.22.4.2 TAB procedures: refer to Section 23 25 00 – HVAC Water Treatment.
- 1.23 OTHER TAB REQUIREMENTS
 - 1.23.1 General requirements applicable to work specified this paragraph:
 - 1.23.1.1 Qualifications of TAB personnel: as for air systems specified this section.
 - 1.23.1.2 Quality assurance: as for air systems specified this section.
 - 1.23.2 Laboratory fume hoods:
 - 1.23.2.1 Standard: ASHRAE 110 – Method of Testing Performance of Laboratory Fume Hoods, applicable provincial standard.
 - 1.23.2.2 TAB procedures: as described in standard.
 - 1.23.3 Building pressure conditions:
 - 1.23.3.1 Adjust HVAC systems, equipment, controls to ensure specified pressure conditions during winter and summer design conditions.
 - 1.23.4 Zone pressure differences:
 - 1.23.4.1 Adjust HVAC systems, equipment, controls to establish specified air pressure differentials, with all systems in all possible combinations of normal operating modes.
 - 1.23.5 Smoke management systems:
 - 1.23.5.1 Test for proper operation of all smoke and fire dampers, sensors, detectors, installed as component parts of air systems specified in other Divisions.

1.23.6 Measurement of noise and vibration from equipment specified in Mechanical Division.

1.23.6.1 Standard: 23 05 48 - Vibration and Seismic Controls for HVAC Piping and Equipment and 23 32 48 - Acoustical Air Plenums.

1.23.6.2 Vibration measurements around each piece of rotating equipment.

1.23.6.3 Sound measurements in each octave band around each piece of rotating equipment.

1.23.6.4 Induct sound measurements in each octave band at each fan inlet and discharge.

1.23.6.5 Induct sound measurements in each octave band at each air handling unit intake, return and discharge.

1.23.6.6 Sound measurements in each octave band for each normally occupied room with air handling equipment running.

1.23.7 Measurement of spatial noise:

1.23.7.1 Standard: Section 23 32 48 - Acoustical Air Plenums.

1.24 POST- OCCUPANCY TAB

1.24.1 Measure DBT, WBT (or %RH), air velocity, air flow patterns, NC levels, in occupied zone of areas designated by Owner.

1.24.2 Participate in systems checks twice during Warranty Period - #1 approximately three (3) months after acceptance and #2 within three (3) months of termination of Warranty Period.

PRODUCTS (NOT APPLICABLE)

EXECUTION (NOT APPLICABLE)

END OF SECTION

SECTION 230594:

PRESSURE TESTING OF DUCTS

1. PART 1 GENERAL

1.1 SUMMARY

1.1.1 Section Includes:

1.1.1.1 Materials and methods for pressure testing ducts over 5 m in length, forming part of a supply, return or exhaust ductwork system directly or indirectly connected to air handling equipment.

1.2 RELATED SECTIONS:

1.2.1 Section 01 33 00 - Submittal Procedures.

1.2.2 Section 01 45 00 - Quality Control.

1.2.3 Section 01 74 21 - Construction/Demolition Waste Management and Disposal.

1.2.4 Section 01 78 00 - Closeout Submittals.

1.2.5 Section 01 91 13.13 - Commissioning (Cx) Requirements.

1.3 REFERENCES

1.3.1 Sheet Metal and Air Conditioning Contractor's National Association (SMACNA)

1.3.1.1 SMACNA HVAC Air Duct Leakage Test Manual.

1.4 SUBMITTALS

1.4.1 Make submittals in accordance with Section 01 33 00 - Submittal Procedures.

1.4.2 Test Reports: submit certified test reports from approved independent testing laboratories indicating compliance with specifications for specified performance characteristics and physical properties. Include pressure test information and results as follows:

1.4.2.1 Submit proposed report form and test report format to Owner for approval at least three (3) months before proposed date of first series of tests. Do not start tests until approval received in writing from Owner.

1.4.2.2 Prepare report of results and submit to Owner within two (2) working days of completion of tests. Include:

1.4.2.2.1 Schematic of entire system.

1.4.2.2.2 Schematic of section under test showing test site.

1.4.2.2.3 Required and achieved static pressures.

1.4.2.2.4 Orifice differential pressure at test sites.

1.4.2.2.5 Permissible and actual leakage flow rate (L/s) for test sites.

1.4.2.2.6 Witnessed certification of results.

1.4.2.3 Include test reports in final TAB report.

1.4.2.4 Certificates: submit certificates signed by manufacturer certifying that materials comply with specified performance characteristics and physical properties.

1.4.2.5 Instructions: submit manufacturer's installation instructions.

1.4.2.6 Manufacturer's field reports specified.

1.5 QUALITY ASSURANCE

1.5.1 Pre-Installation Meetings:

1.5.1.1 Convene pre-installation meeting one week prior to beginning work of this Section and on-site installations.

1.5.1.1.1 Verify project requirements.

1.5.1.1.2 Review installation and substrate conditions.

1.5.1.1.3 Co-ordination with other building subtrades.

1.5.1.1.4 Review manufacturer's installation instructions and warranty requirements.

1.5.1.2 Health and Safety:

1.5.1.2.1 Do construction occupational health and safety in accordance Safety Requirements.

2. PART 2 PRODUCTS

2.1 TEST INSTRUMENTS

2.1.1 Test apparatus to include:

2.1.1.1 Fan capable of producing required static pressure.

2.1.1.2 Duct section with calibrated orifice plate mounted and accurately located pressure taps.

2.1.1.3 Flow measuring instrument compatible with the orifice plate.

2.1.1.4 Calibration curves for orifice plates used.

2.1.1.5 Flexible duct for connecting to ductwork under test.

2.1.1.6 Smoke bombs for visual inspections.

2.1.2 Test apparatus: accurate to within +/- 3 % of flow rate and pressure.

2.1.3 Submit details of test instruments to be used to Owner at least three (3) months before anticipated start date.

- 2.1.4 Test instruments: calibrated and certificate of calibration deposited with Owner no more than 28 days before start of tests.
- 2.1.5 Re-calibrated every six (6) months thereafter.
- 2.2 EQUIPMENT LEAKAGE TOLERANCES
 - 2.2.1 Equipment and system components such as VAV boxes, duct heating leakage: 2%.
- 3. PART 3 EXECUTION
 - 3.1 MANUFACTURER'S INSTRUCTIONS
 - 3.1.1 Compliance: comply with manufacturer's written recommendations or specifications, including product technical bulletins, handling, storage and installation instructions, and datasheet.
 - 3.2 TEST PROCEDURES
 - 3.2.1 Maximum lengths of ducts to be tested consistent with capacity of test equipment.
 - 3.2.2 Section of duct to be tested to include:
 - 3.2.2.1 Fittings, branch ducts, tap-ins.
 - 3.2.3 Repeat tests until specified pressures are attained. Bear costs for repairs and repetition to tests.
 - 3.2.4 Base partial system leakage calculations on SMACNA HVAC Air Duct Leakage Test Manual.
 - 3.2.5 Seal leaks that can be heard or felt, regardless of their contribution to total leakage.
 - 3.3 SITE TOLERANCES
 - 3.3.1 System leakage tolerances specified are stated as percentage of total flow rate handled by system. Pro-rate specified system leakage tolerances. Leakage for sections of duct systems: not to exceed total allowable leakage.
 - 3.3.2 Leakage tests on following systems not to exceed specified leakage rates.
 - 3.3.2.1 Small duct systems up to 250 Pa: leakage 2 %.
 - 3.3.2.2 VAV box and duct on downstream side of VAV box: leakage 2 %.
 - 3.3.2.3 Large low pressure duct systems up to 500 Pa: leakage 2 %.
 - 3.3.2.4 HP duct systems up to 1000 Pa pressure classification, including upstream side of VAV boxes: leakage 1%.
 - 3.3.3 Evaluation of test results to use surface area of duct and pressure in duct as basic parameters.
 - 3.4 TESTING
 - 3.4.1 Test ducts before installation of insulation or other forms of concealment.
 - 3.4.2 Test after seals have cured.
 - 3.4.3 Test when ambient temperature will not affect effectiveness of seals, and gaskets.
 - 3.4.4 Flexible connections to VAV boxes.
 - 3.5 FIELD QUALITY CONTROL
 - 3.5.1 Manufacturer's Field Services.
 - 3.5.1.1 Have manufacturer of products, supplied under this Section, review Work involved in the handling, installation/application, and protection and cleaning, of its products and submit written reports, in acceptable format, to verify compliance of Work with Contract.
 - 3.5.1.2 Manufacturer's Field Services: provide manufacturer's field services consisting of product use recommendations and periodic site visits for inspection of product installation in accordance with manufacturer's instructions.
 - 3.5.1.3 Schedule site visits, to review Work, at stages listed:

3.5.1.3.1 After delivery and storage of products, and when preparatory Work, or other Work, on which the Work of this Section depends, is complete but before installation begins.

3.5.1.3.2 Twice during progress of Work at 25% and 60% complete.

3.5.1.3.3 Upon completion of the Work, after cleaning is carried out.

3.5.1.4 Obtain reports, within three (3) days of review, and submit, immediately, to Owner.

3.5.2 Performance Verification:

3.5.2.1 Owner to witness tests and to verify reported results.

3.5.2.2 To be certified by same TAB agency approved by Owner to undertake TAB on this project.

3.6 CLEANING

3.6.1 Upon completion and verification of performance of installation, remove surplus materials, excess materials, rubbish, tools and equipment.

END OF SECTION

SECTION 230713:**DUCT INSULATION****1. PART1 GENERAL****1.1 RELATED SECTIONS**

- 1.1.1 Section 01 33 00 - Submittal Procedures.
- 1.1.2 Section 01 74 21 - Construction/Demolition Waste Management and Disposal
- 1.1.3 Section 23 05 29 - Hangers and Supports for HVAC Piping and Equipment
- 1.1.4 Section 23 05 53.01 - Mechanical Identification.

1.2 REFERENCES

- 1.2.1 American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE)
 - 1.2.1.1 ANSI/ASHRAE/IESNA 90.1, SI; Energy Standard for Buildings Except Low-Rise Residential Buildings.
- 1.2.2 American Society for Testing and Materials International, (ASTM)
 - 1.2.2.1 ASTM B209M, Specification for Aluminum and Aluminum Alloy Sheet and Plate (Metric).
 - 1.2.2.2 ASTM C335, Test Method for Steady State Heat Transfer Properties of Horizontal Pipe Insulation.
 - 1.2.2.3 ASTM C411, Test Method for Hot-Surface Performance of High-Temperature Thermal Insulation.
 - 1.2.2.4 ASTM C449/C449M, Standard Specification for Mineral Fiber-Hydraulic-Setting Thermal Insulating and Finishing Cement.
 - 1.2.2.5 ASTM C547, Specification for Mineral Fiber Pipe Insulation.
 - 1.2.2.6 ASTM C553, Specification for Mineral Fiber Blanket Thermal Insulation for Commercial and Industrial Applications.
 - 1.2.2.7 ASTM C612, Specification for Mineral Fiber Block and Board Thermal Insulation.
 - 1.2.2.8 ASTM C795, Specification for Thermal Insulation for Use with Austenitic Stainless Steel.
 - 1.2.2.9 ASTM C921, Standard Practice for Determining Properties of Jacketing Materials for Thermal Insulation.
- 1.2.3 Canadian General Standards Board (CGSB)
 - 1.2.3.1 CGSB 51-GP-52Ma, Vapour Barrier, Jacket and Facing Material for Pipe, Duct and Equipment Thermal Insulation.
- 1.2.4 Thermal Insulation Association of Canada (TIAC): National Insulation Standards.
- 1.2.5 Underwriters Laboratories of Canada (ULC)
 - 1.2.5.1 CAN/ULC-S102, Surface Burning Characteristics of Building Materials and Assemblies.
- 1.2.6 National Energy Code of Canada for Buildings (NECB)

1.3 DEFINITIONS

- 1.3.1 For purposes of this section:
 - 1.3.1.1 "CONCEALED" - insulated mechanical services and equipment in suspended ceilings and non-accessible chases and furred-in spaces.
 - 1.3.1.2 "EXPOSED" - will mean "not concealed" as defined herein.
 - 1.3.1.3 Insulation systems - insulation material, fasteners, jackets, and other accessories.
- 1.3.2 TIAC Codes:
 - 1.3.2.1 CRD: Commercial Round Ductwork,
 - 1.3.2.2 CRF: Commercial Rectangular Finish.

1.4 SHOP DRAWINGS

- 1.4.1 Submit shop drawings in accordance with Section 01 33 00 - Submittal Procedures.

- 1.4.2 Submit for approval manufacturer's catalogue literature related to installation, fabrication for duct jointing recommendations.
- 1.5 SAMPLES
 - 1.5.1 Submit samples in accordance with Section 01 33 00 - Submittal Procedures.
 - 1.5.2 Submit for approval: complete assembly of each type of insulation system, insulation, coating, and adhesive proposed. Mount sample on 12 mm plywood board. Affix typewritten label beneath sample indicating service.
- 1.6 MANUFACTURERS' INSTRUCTIONS
 - 1.6.1 Submit manufacturer's installation instructions in accordance with Section 01 33 00 - Submittal Procedures.
 - 1.6.2 Installation instructions to include procedures used and installation standards achieved.
- 1.7 QUALIFICATIONS
 - 1.7.1 Installer: certified in performing work of this section, and have at least 5 years successful experience in this size and type of project, qualified to standards of TIAC.
- 1.8 DELIVERY, STORAGE AND HANDLING
 - 1.8.1 Deliver materials to site in original factory packaging, labelled with manufacturer's name, address.
 - 1.8.2 Protect from weather and construction traffic.
 - 1.8.3 Protect against damage from any source.
 - 1.8.4 Store at temperatures and conditions recommended by manufacturer.
- 1.9 WASTE MANAGEMENT AND DISPOSAL
 - 1.9.1 Separate and recycle waste materials in accordance with Section 01 74 21 - Construction / Demolition Waste Management and Disposal.
 - 1.9.2 Remove from site and dispose of packaging materials at appropriate recycling facilities.
 - 1.9.3 Collect and separate for disposal, paper, plastic, polystyrene, corrugated cardboard packaging material in appropriate on-site bins for recycling in accordance with Waste Management Plan.
 - 1.9.4 Divert unused metal materials from landfill to metal recycling facility approved by Owner.
 - 1.9.5 Divert unused adhesive material from landfill to official hazardous material collections site approved by Owner.
 - 1.9.6 Do not dispose of unused adhesive materials into sewer systems, into lakes, streams, onto ground or in other locations where it will pose health or environmental hazard.
- 2. PART 2 PRODUCTS
 - 2.1 FIRE AND SMOKE RATING
 - 2.1.1 In accordance with CAN/ULC-S102:
 - 2.1.1.1 Maximum flame spread rating: 25.
 - 2.1.1.2 Maximum smoke developed rating: 50.
 - 2.2 INSULATION
 - 2.2.1 Mineral fibre: as specified includes glass fibre, rock wool, slag wool.
 - 2.2.2 Thermal conductivity ("k" factor) not to exceed specified values at 24°C mean temperature when tested in accordance with ASTM C335.
 - 2.2.3 TIAC Code C-1: Rigid mineral fibre board to ASTM C612, with factory applied vapour retarder jacket to CGSB 51-GP-52Ma (as scheduled in PART 3 of this Section).
 - 2.2.4 TIAC Code C-2: Mineral fibre blanket to ASTM C553 faced with factory applied vapour retarder jacket to CGSB 51-GP-52Ma (as scheduled in PART 3 of this section).

- 2.2.4.1 Mineral fibre: to ASTM C553.
- 2.2.4.2 Jacket: to CGSB 51-GP-52Ma.
- 2.2.4.3 Maximum "k" factor: to ASTM C553.

2.3 JACKETS

- 2.3.1 Canvas:
 - 2.3.1.1 220 gm/m² cotton, plain weave, treated with dilute fire retardant lagging adhesive to ASTM C921.
- 2.3.2 Lagging adhesive: Compatible with insulation.
- 2.3.3 Aluminum:
 - 2.3.3.1 To ASTM B209 with moisture barrier as scheduled in PART 3 of this section.
 - 2.3.3.2 Thickness: 0.40 mm sheet.
 - 2.3.3.3 Finish: Stucco embossed or corrugated.
 - 2.3.3.4 Jacket banding and mechanical seals: 12 mm wide, 0.5 mm thick stainless steel.
- 2.3.4 Stainless steel:
 - 2.3.4.1 Type: 304 or 316 where additional corrosion protection is required.
 - 2.3.4.2 Thickness: 0.25 mm sheet.
 - 2.3.4.3 Finish: Corrugated or stucco embossed.
 - 2.3.4.4 Jacket banding and mechanical seals: 12mm wide, 0.5 mm thick stainless steel.

2.4 ACCESSORIES

- 2.4.1 Vapour retarder lap adhesive:
 - 2.4.1.1 Water based, fire retardant type, compatible with insulation.
- 2.4.2 Indoor Vapour Retarder Finish:
 - 2.4.2.1 Vinyl emulsion type acrylic, compatible with insulation.
- 2.4.3 Insulating Cement: hydraulic setting on mineral wool, to ASTM C449.
- 2.4.4 ULC Listed Canvas Jacket:
 - 2.4.4.1 220 gm/m² cotton, plain weave, treated with dilute fire retardant lagging a
 - 2.4.4.2 Dhesive to ASTM C921.
- 2.4.5 Outdoor Vapour Retarder Mastic:
 - 2.4.5.1 Vinyl emulsion type acrylic, compatible with insulation.
 - 2.4.5.2 Reinforcing fabric: Fibrous glass, untreated 305 g/m².
- 2.4.6 Tape: self-adhesive, aluminum, reinforced, 75 mm wide minimum.
- 2.4.7 Contact adhesive: quick-setting
- 2.4.8 Canvas adhesive: washable.
- 2.4.9 Tie wire: 1.5 mm stainless steel.
- 2.4.10 Banding: 12 mm wide, 0.5 mm thick stainless steel.
- 2.4.11 Facing: 25 mm galvanized steel hexagonal wire mesh stitched on one face of insulation.
- 2.4.12 Fasteners: 4 mm diameter pins with 35 mm diameter or square clips, length to suit thickness of insulation.

3. PART 3 EXECUTION

3.1 PRE-INSTALLATION REQUIREMENTS

- 3.1.1 Pressure testing of ductwork systems complete, witnessed and certified.
- 3.1.2 Surfaces clean, dry, free from foreign material.

3.2 INSTALLATION

- 3.2.1 Install in accordance with TIAC National Standards.
- 3.2.2 Apply materials in accordance with manufacturer's instructions and as indicated.

- 3.2.3 Use two layers with staggered joints when required nominal thickness exceeds 75 mm.
- 3.2.4 Maintain uninterrupted continuity and integrity of vapour retarder jacket and finishes.
- 3.2.4.1 Hangers, supports to be outside vapour retarder jacket.
- 3.2.5 Supports, Hangers in accordance with Section 23 05 29 - Hangers and Supports for HVAC Piping and Equipment
- 3.2.5.1 Apply high compressive strength insulation where insulation may be compressed by weight of ductwork.
- 3.2.6 Fasteners: At 300 mm oc in horizontal and vertical directions, minimum two rows each side.

3.3 DUCTWORK INSULATION SCHEDULE

- 3.3.1 Insulation types and thicknesses: Conform to following Table:

	TIAC Code	Vapour Retarder	Thickness (mm)
Rectangular cold and dual temperature supply air ducts (exposed)	C-1	yes	50
Round cold and dual temperature supply air ducts (concealed)	C-2	yes	50
Rectangular warm air ducts (exposed)	C-1	no	25
Round warm air ducts (exposed)	C-1	no	25
Rectangular cold and dual temperature supply air ducts (concealed)	C-2	Yes	25
Round cold and dual temperature supply air ducts (exposed)	C-1	yes	50
Rectangular warm air ducts (concealed)	C-2	No	25
Round warm air ducts (concealed)	C-2	No	25
Supply, return and exhaust ducts exposed in space being served			none
Outside air ducts to mixing plenum	C-1	yes	50
Mixing plenums	C-1	yes	25
Exhaust duct between dampers and louvers	C-1	no	50
Rectangular ducts outside	C-1	special	50
Round ducts outside	C-1	special	50
Acoustically lined ducts	See Section 23 33 53- Duct Liners		

- 3.3.2 Exposed round ducts 600 mm and larger, smaller sizes where subject to abuse:

- 3.3.2.1 Use TIAC code C-1 insulation, scored to suit diameter of duct.

- 3.3.3 Finishes: Conform to following table:

	TIAC Code	
	Rectangular	Round
Indoor, concealed	None	none
Indoor, exposed within mechanical room	CRF/1	CRD/2
Indoor, exposed elsewhere	CRF/2	CRD/3
Outdoor, exposed to precipitation	CRF/3	CRD/4
Outdoor, elsewhere	CRF/4	CRD/5

END OF SECTION

SECTION 230716:**HVAC EQUIPMENT INSULATION****1. PART 1 GENERAL****1.1 RELATED SECTIONS**

- 1.1.1 Section 01 33 00 - Submittal Procedures.
- 1.1.2 Section 01 74 21 - Construction/Demolition Waste Management and Disposal
- 1.1.3 Section 23 05 29 - Hangers and Supports for HVAC Piping and Equipment.
- 1.1.4 Section 23 05 53.01 - Mechanical Identification.

1.2 REFERENCES

- 1.2.1 American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE)
 - 1.2.1.1 ANSI/ASHRAE/IESNA 90.1 SI, Energy Standard for Buildings except Low-Rise Residential Buildings.
- 1.2.2 American Society for Testing and Materials (ASTM International)
 - 1.2.2.1 ASTM B209M, Specification for Aluminum and Aluminum Alloy Sheet and Plate.
 - 1.2.2.2 ASTM C335, Test Method for Steady State Heat Transfer Properties of Horizontal Pipe Insulation.
 - 1.2.2.3 ASTM C411, Test Method for Hot-Surface Performance of High-Temperature Thermal Insulation.
 - 1.2.2.4 ASTM C449/C449M, Specification for Mineral Fiber-Hydraulic-Setting Thermal Insulating and Finishing Cement.
 - 1.2.2.5 ASTM C533, Specification for Calcium Silicate Block and Pipe Thermal Insulation.
 - 1.2.2.6 ASTM C547, Specification for Mineral Fiber Pipe Insulation.
 - 1.2.2.7 ASTM C553, Specification for Mineral Fiber Blanket Thermal Insulation for Commercial and Industrial Applications.
 - 1.2.2.8 ASTM C612, Specification for Mineral Fiber Block and Board Thermal Insulation.
 - 1.2.2.9 ASTM C795, Standard Specification for Thermal Insulation for Use in Contact with Austenitic Stainless Steel.
 - 1.2.2.10 ASTM C921, Practice for Determining the Properties of Jacketing Materials for Thermal Insulation.
- 1.2.3 Canadian General Standards Board (CGSB)
 - 1.2.3.1 CGSB 51-GP-52Ma, Vapour Barrier, Jacket and Facing Material for Pipe, Duct and Equipment Thermal Insulation.
- 1.2.4 Thermal Insulation Association of Canada (TIAC)
 - 1.2.4.1 National Insulation Standards.
- 1.2.5 Underwriters Laboratories of Canada (ULC)
 - 1.2.5.1 CAN/ULC-S102, Surface Burning Characteristics of Building Materials and Assemblies.
- 1.2.6 National Energy Code of Canada for Buildings (NECB).

1.3 PRODUCT DATA

- 1.3.1 Submit Product Data in accordance with Section 01 33 00 - Submittal Procedures.

1.4 SAMPLES

- 1.4.1 Submit samples in accordance with Section 01 33 00 - Submittal Procedures.
- 1.4.2 Submit for approval: complete assembly of each type of insulation system, insulation, coating, and adhesive proposed. Mount sample on 12 mm plywood board. Affix typewritten label beneath sample indicating service.

1.5 MANUFACTURER'S INSTRUCTIONS

- 1.5.1 Submit manufacturer's installation instructions in accordance with 01 33 00 - Submittal Procedures.
- 1.5.2 Installation instructions to include procedures to be used, installation standards to be achieved.

1.6 QUALIFICATIONS

- 1.6.1 Installer to be certified in performing work of this section, and have at least 5 years successful experience in this size and type of project, qualified to standards of TIAC.

1.7 DELIVERY, STORAGE AND HANDLING

- 1.7.1 Deliver materials to site in original factory packaging, labelled with manufacturer's name, address.
- 1.7.2 Protect from weather and construction traffic.
- 1.7.3 Protect against damage from any source.
- 1.7.4 Store at temperatures and conditions recommended by manufacturer.

1.8 WASTE MANAGEMENT AND DISPOSAL

- 1.8.1 Separate and recycle waste materials in accordance with Section 01 74 21 - Construction/Demolition Waste Management And Disposal.
- 1.8.2 Remove from site and dispose of packaging materials at appropriate recycling facilities.
- 1.8.3 Collect and separate for disposal, paper, plastic, polystyrene, corrugated cardboard, packaging material in appropriate on-site for recycling in accordance with Waste Management Plan.
- 1.8.4 Divert unused metal materials from landfill to metal recycling facility approved by Owner.
- 1.8.5 Divert unused adhesive materials from landfill to official hazardous material collections site approved by Owner.
- 1.8.6 Do not dispose of unused adhesive materials into sewer systems, into lakes, streams, onto ground or in other location where it will pose health or environmental hazard.

2. PART 2 PRODUCTS**2.1 FIRE AND SMOKE RATING**

- 2.1.1 In accordance with CAN/ULC-S102:
 - 2.1.1.1 Maximum flame spread rating: 25.
 - 2.1.1.2 Maximum smoke developed rating: 50.

2.2 INSULATION

- 2.2.1 Mineral fibre: includes glass fibre, rock wool, slag wool.
- 2.2.2 Thermal conductivity ("k" factor) not to exceed specified values at 24°C mean temperature when tested in accordance with ASTM C335.
- 2.2.3 TIAC Code A-1: Rigid moulded mineral fibre without factory applied vapour retarder jacket.
 - 2.2.3.1 Mineral fibre: ASTM C547.
 - 2.2.3.2 Maximum "k" factor: ASTM C547.
- 2.2.4 TIAC Code A-2: Rigid moulded calcium silicate in sections and blocks, and with special shapes to suit project requirements.
 - 2.2.4.1 Insulation: ASTM C533.
 - 2.2.4.2 Maximum "k" factor: ASTM C533.
 - 2.2.4.3 Design to permit periodic removal and re-installation
- 2.2.5 TIAC Code A-3: Rigid moulded mineral fibre with factory applied vapour retarder jacket.
 - 2.2.5.1 Mineral fibre: ASTM C547.

- 2.2.5.2 Jacket: to CGSB 51-GP-52Ma.
- 2.2.5.3 Maximum "k" factor: ASTM C547.
- 2.2.6 TIAC Code A-6: Flexible unicellular tubular elastomer.
 - 2.2.6.1 Insulation: with vapour retarder jacket to ASTM C534.
 - 2.2.6.2 Jacket: to CGSB 51-GP-52Ma.
 - 2.2.6.3 Maximum "k" factor: C534.
 - 2.2.6.4 Certified by manufacturer free of potential stress corrosion cracking corrodants.
 - 2.2.6.5 Flame spread index less than 25, and smoke developed index less than 50.
- 2.2.7 TIAC Code C-1: Rigid mineral fibre board, unfaced.
 - 2.2.7.1 Mineral fibre: ASTM C612.
 - 2.2.7.2 Maximum "k" factor: ASTM C612.
- 2.2.8 TIAC Code C-2: Mineral fibre blanket unfaced or faced with factory applied vapour retarder jacket (as scheduled in PART 3 of this section).
 - 2.2.8.1 Mineral fibre: ASTM C553.
 - 2.2.8.2 Jacket: to CGSB 51-GP-52Ma.
 - 2.2.8.3 Maximum "k" factor: ASTM C553.
- 2.2.9 TIAC Code C-4: Rigid mineral fibre board faced with factory applied vapour retarder jacket.
 - 2.2.9.1 Mineral fibre: ASTM C612.
 - 2.2.9.2 Jacket: to CGSB 51-GP-52Ma.
 - 2.2.9.3 Maximum "k" factor: ASTM C612.
- 2.3 CEMENT
 - 2.3.1 Thermal insulating and finish
 - 2.3.1.1 To: ASTM C449/C449M.
 - 2.3.1.2 Hydraulic setting or air drying on mineral wool, to ASTM C449.
- 2.4 JACKETS
 - 2.4.1 Polyvinyl Chloride (PVC):
 - 2.4.1.1 One-piece molded type and sheet to CGSB 51-GP-53M with pre-formed shapes as required.
 - 2.4.1.2 Colours: to match adjacent finish paint. Confirm with Owner.
 - 2.4.1.3 Minimum service temperatures: -20°C.
 - 2.4.1.4 Maximum service temperature: 65°C.
 - 2.4.1.5 Moisture vapor transmission: 0.02 perm.
 - 2.4.1.6 Thickness: 0.56 mm.
 - 2.4.1.7 Fastenings:
 - 2.4.1.7.1 Use solvent weld adhesive compatible with insulation to seal laps and joints.
 - 2.4.1.7.2 Tacks.
 - 2.4.1.7.3 Pressure sensitive vinyl tape of matching color.
 - 2.4.1.8 Special requirements:
 - 2.4.1.8.1 Indoor: flame spread rating 25. Smoke developed 50.
 - 2.4.1.8.2 Outdoor: UV rated material at least 0.5 mm thick.
 - 2.4.1.9 Covering adhesive: Compatible with insulation.
 - 2.4.2 Canvas:
 - 2.4.2.1 220 gm/m² cotton, plain weave, treated with dilute fire retardant lagging adhesive to ASTM C921.
 - 2.4.2.2 Lagging adhesive: Compatible with insulation.
 - 2.4.3 Aluminum:
 - 2.4.3.1 To ASTM B209.
 - 2.4.3.2 Thickness: 0.50 mm sheet.

- 2.4.3.3 Finish: Stucco embossed or corrugated.
- 2.4.3.4 Joining: Longitudinal and circumferential slip joints with 50 mm laps.
- 2.4.3.5 Fittings: 0.5 mm thick die-shaped fitting covers with factory-attached protective liner.
- 2.4.3.6 Metal jacket banding and mechanical seals: stainless steel, 19 mm wide, 0.5 mm thick at 300 mm spacing.
- 2.4.4 Stainless steel:
 - 2.4.4.1 Type: 304 or 316.
 - 2.4.4.2 Thickness: 0.25 mm.
 - 2.4.4.3 Finish: Smooth, corrugated or stucco embossed.
 - 2.4.4.4 Joining: Longitudinal and circumferential slip joints with 50 mm laps.
 - 2.4.4.5 Fittings: 0.50 mm thick die-shaped fitting covers with factory-attached protective liner.
 - 2.4.4.6 Metal jacket banding and mechanical seals: stainless steel, 19 mm wide, 0.5 mm thick at 300 mm spacing.
- 2.5 REMOVABLE INSULATION COVERS
 - 2.5.1 General:
 - 2.5.1.1 All Covers shall be sewn, stapled or "hog-ringed" covers shall not be acceptable.
 - 2.5.1.2 Covers shall conform to the configuration of the items being insulated.
 - 2.5.1.3 Covers shall include openings for all protrusions such as pipes, packing glands on valves and expansion joints, hangers, supports, instrument lines, and other appurtenances.
 - 2.5.1.4 Covers shall be designed so that no force bending or folding of the cover is necessary for installation.
 - 2.5.1.5 Minimum 50mm wide flaps at terminal ends are to be provided to overlap adjacent covers to ensure a good heat seal.
 - 2.5.1.6 Parting seems shall be at the installed low points (gravitational bottom) of the cover to allow drainage without the use of weep tubes or grommets.
 - 2.5.1.7 Valve bonnets are to be covered, but packing glands shall remain exposed.
 - 2.5.1.8 Valve covers are to be designed such that the bonnet section is sewn to the body section. For larger valves, the cover may be fabricated in two sections, each section containing one half of the valve body and bonnet.
 - 2.5.1.9 Covers with a weight of 18.1 Kg or less are to be fabricated in one piece.
 - 2.5.1.10 Covers with a weight of more than 18.1 Kg are to be fabricated in more than one piece.
 - 2.5.2 Insulation Core:
 - 2.5.2.1 The insulation core shall be fabricated in one piece, wherever possible.
 - 2.5.2.2 To prevent insulation settlement, the insulation core shall be secured within the jacket through the weather barrier (outer jacketing), the insulation, and the liner (inner jacketing).
 - 2.5.2.3 Insulating cores with more than one piece shall have staggered joints to prevent hot spots and heat loss. The joint edges shall be butted together and extra securement provided at those edges.
 - 2.5.2.4 Insulation core shall be comprised of 50mm thick fiberglass insulation of non-combustible wool with resilient inorganic glass fibers bonded with a thermosetting resin. Insulation density to be 38 Kg/m³. Insulation

thermal conductivity to be 0.044W/m.°C at a mean temperature of 100°C.

2.5.3 Jacket:

- 2.5.3.1 The jacket shall be fabricated in one piece, wherever possible.
- 2.5.3.2 Gusset walls shall be required for covers with core insulation thickness in excess of 25mm.
- 2.5.3.3 All seams, except the final closing seam, shall be inside seams. The jackets are to be sewn inside out, then turned correct side out before inserting the insulation core. The final closing seam shall be sewn on the exterior of the jacket. Seams shall be sewn with Teflon® coated fiberglass thread or Kevlar® coated stainless steel thread.
- 2.5.3.4 Machine stitching shall be used for all sewing. Sewing shall be 6-8 stitches per centimeter.
- 2.5.3.5 Draw cords are to be placed along the outer edge of the flap and the outer edge of the flap then rolled back inside and double stitched.
- 2.5.3.6 Draw cords are to be of sufficient length to allow 150mm of cord to protrude from each side of the flap.
- 2.5.3.7 The inner and outer jacket shall be comprised of a fiberglass fabric impregnated with silicone rubber. The silicone rubber shall be flame retardant and suitable for high temperature usage. Outer jacket density shall be 595 gms/m².

2.5.4 Securement devices:

- 2.5.4.1 The securement belts and D-ring belts shall be of the same material as the weather barrier (exterior jacket).
- 2.5.4.2 The belts shall be placed 50mm back from the parting seams and on 150mm centers.
- 2.5.4.3 Fire retardant Velcro® shall be used to fasten the securement belt to the weather barrier after the belt passed through the Stainless Steel D-rings.

2.5.5 Identification tags:

- 2.5.5.1 Each cover shall be identified by a permanently attached stainless steel tag.
- 2.5.5.2 An identification legend shall be mechanically embossed into the tag.
- 2.5.5.3 The tags shall be located in the same areas on similar type covers.
- 2.5.5.4 Should a cover require more than one piece for its construction, each piece to be identified and numbered (i.e. 1 of 3).
- 2.5.5.5 Each tag shall include at least the following information, but may also include any pertinent information required by the end user.
 - 2.5.5.5.1 Type of item being covered.
 - 2.5.5.5.2 Location of item.
 - 2.5.5.5.3 Recording and tracking information.

2.5.5.6 Warranty:

- 2.5.5.6.1 Provide a 5-year product Warranty

2.6 INSULATION SECUREMENTS

- 2.6.1 Tape: Self-adhesive, aluminum, reinforced, 50 mm wide minimum.
- 2.6.2 Contact adhesive: Quick setting.
- 2.6.3 Canvas adhesive: Washable.
- 2.6.4 Tie wire: 1.5 mm diameter stainless steel.
- 2.6.5 Bands: Stainless steel, 19 mm wide, 0.5 mm thick.
- 2.6.6 Facing: 25 mm galvanized steel hexagonal wire mesh on one face of insulation.

- 2.6.7 Fasteners: 4 mm diameter pins with 35 mm diameter or square clips. Length of pin to suit thickness of insulation.
- 2.7 VAPOUR RETARDER LAP ADHESIVE
 - 2.7.1 Water based, fire retardant type, compatible with insulation.
- 2.8 INDOOR VAPOUR RETARDER FINISH
 - 2.8.1 Vinyl emulsion type acrylic, compatible with insulation.
 - 2.8.2 Reinforcing fabric: Fibrous glass, untreated 305 g/m².
- 2.9 OUTDOOR VAPOUR RETARDER MASTIC
 - 2.9.1 Vinyl emulsion type acrylic, compatible with insulation.
 - 2.9.2 Reinforcing fabric: Fibrous glass, untreated 305 g/m².
- 3. PART 3 EXECUTION
 - 3.1 PRE- INSTALLATION REQUIREMENTS
 - 3.1.1 Pressure testing of equipment and adjacent piping systems complete, witnessed and certified.
 - 3.1.2 Surfaces clean, dry, free from foreign material.
 - 3.2 INSTALLATION
 - 3.2.1 Install in accordance with TIAC National Standards
 - 3.2.1.1 Hot equipment: To TIAC code 1503-H.
 - 3.2.1.2 Cold equipment: to TIAC code 1503-C or 1503-CA.
 - 3.2.2 Elastomeric Insulation: to remain dry. Overlaps to manufacturer's instructions. Joints tight and sealed properly.
 - 3.2.3 Provide vapour retarder as recommended by manufacturer.
 - 3.2.4 Apply materials in accordance with insulation and equipment manufacturer's instructions and this specification.
 - 3.2.5 Use two layers with staggered joints when required nominal wall thickness exceeds 75 mm.
 - 3.2.6 Maintain uninterrupted continuity and integrity of vapour retarder jacket and finishes.
 - 3.2.6.1 Hangers, supports outside vapour retarder jacket.
 - 3.2.7 Supports, Hangers:
 - 3.2.7.1 Apply high compressive strength insulation, suitable for service, at oversized saddles and shoes where insulation saddles have not been provided.
 - 3.3 EQUIPMENT INSULATION SCHEDULES
 - 3.3.1 Includes valves, valve bonnets, strainers, flanges and fittings unless otherwise specified.
 - 3.3.2 Hot Equipment:
 - 3.3.2.1 TIAC code A-1 or C-1 with mechanical fastenings or wire or bands and 13 mm cement reinforced with one layer of reinforcing mesh.
 - 3.3.2.2 TIAC code A-2 with 25 mm air gap, mechanical fastenings or wire or bands and 13 mm cement reinforced with one layer of reinforcing mesh.
 - 3.3.2.3 TIAC code C-2 unfaced with wire or bands and 13 mm cement preceded by one layer of reinforcing mesh.
 - 3.3.2.4 Thicknesses:
 - 1) Domestic hot water storage tanks 25 mm
 - 2) Shell and tube heat exchangers 50 mm
 - 3) Steam condensate receivers 50 mm
 - 4) Deaerator-feed water heaters 50 mm
 - 5) Chilled and hot water buffer tanks
 - 3.3.3 Breechings, engine exhausts and mufflers:

- 3.3.3.1 TIAC code A-2 with 25 mm air gap, mechanical fastenings or wire or bands and 13 mm cement reinforced with one layer of reinforcing mesh.
- 3.3.3.2 Cement reinforced with one layer of reinforcing mesh.
- 3.3.4 Cold equipment:
 - 3.3.4.1 TIAC A-3 or C-4 with mechanical fastenings or wire or bands and 13 mm cement reinforced with one layer of reinforcing mesh.
 - 3.3.4.2 TIAC C-2 faced with vapour retardant jacket and with wire or bands and 13 mm cement preceded by one layer of reinforcing mesh.
 - 3.3.4.3 TIAC A-6 or C-4 with mechanical fastenings or wire or bands, adhesive.
 - 3.3.4.3.1 Thicknesses: Chillers (except factory insulated) 50 mm A-3, A-6 or C-4.
- 3.3.5 Finishes:
 - 3.3.5.1 Engine exhaust piping and muffler: To TIAC code CEF-4.
 - 3.3.5.2 Equipment in mechanical rooms: TIAC code CEF/1 with aluminum jacket.
 - 3.3.5.3 Equipment elsewhere: TIAC code CEF/2 with 13 mm cement and canvas jacket.
- 3.4 REMOVABLE INSULATION COVERS
 - 3.4.1 Installation to permit movement of expansion joint and to permit periodic removal and replacement without damage to adjacent insulation.
 - 3.4.2 Removable insulation covers shall be provided for the following:
 - 3.4.2.1 Domestic water service entrance backflow preventer.
 - 3.4.2.2 Domestic water service entrance pressure reducing valve assembly.
 - 3.4.2.3 Domestic water service entrance O.S. & Y gate valve.
 - 3.4.2.4 Domestic water service entrance copper connection butterfly valves NPS 2½ and larger.
 - 3.4.2.5 Domestic water service entrance wye -strainer.
 - 3.4.2.6 Domestic hot water service pump assemblies.
 - 3.4.2.7 Hydronic heating and chilled water system pump assemblies: -pumps, suction diffusers, triple duty valves.
 - 3.4.2.8 Hydronic heating and chilled water system valves NPS 2½ and larger - gate, globe and butterfly.
 - 3.4.2.9 Hydronic heating and chilled water system flex connections, expansion joints.
 - 3.4.2.10 Hydronic heating and chilled water system expansion tanks.
 - 3.4.2.11 Hydronic heating and chilled water system air separators.
 - 3.4.2.12 Hydronic heating and chilled water system plate and frame heat exchangers.
 - 3.4.2.13 Hydronic heating and chilled water system shell and tube heat exchanger's removable heads.
 - 3.4.2.14 Balancing valves NPS 2½ and above.
 - 3.4.2.15 Two-Way Control valves NPS 2½ and larger.
 - 3.4.2.16 Three-Way Control valves NPS 2½ and larger.

END OF SECTION**SECTION 230802: CLEANING AND START-UP OF MECHANICAL PIPING SYSTEMS****1. PART 1 GENERAL****1.1 RELATED SECTIONS**

- 1.1.1 Section 01 91 13.13 - Commissioning (Cx) Requirements: supplemented as specified herein.

- 1.1.2 Section 22 05 15 – Plumbing Specialties and Accessories.
- 1.1.3 Section 23 05 93 – Testing, Adjusting and Balancing for HVAC.
- 1.1.4 Section 23 08 02 – Cleaning and Start-up of Mechanical Piping Systems.
- 1.1.5 Section 23 11 13 – Facility Fuel-Oil Piping.
- 1.1.6 Section 22 11 18 – Domestic Water Piping Copper.
- 1.1.7 Section 23 21 13.02 – Hydronic Systems: Steel.
- 1.1.8 Section 23 23 00 – Copper Tubing and Fittings Refrigerant.

1.2 REFERENCES

- 1.2.1 ASTM E202, Standard Test Methods for Analysis of Ethylene Glycols and Propylene Glycols.

1.3 CLEANING AND START-UP OF MECHANICAL PIPING SYSTEMS

- 1.3.1 In accordance with Section 23 08 02 - Cleaning and Start-up of Mechanical Piping Systems.

1.4 HYDRONIC SYSTEMS - PERFORMANCE VERIFICATION (PV)

- 1.4.1 Perform hydronic systems performance verification after cleaning is completed and system is in full operation.
- 1.4.2 When systems are operational, perform following tests:
 - 1.4.2.1 Conduct full scale tests at maximum design flow rates, temperatures and pressures for continuous consecutive period of two (2) working days to demonstrate compliance with design criteria.
 - 1.4.2.2 Verify performance of hydronic system circulating pumps as specified in relevant technical sections, recording system pressures, temperatures, fluctuations by simulating maximum design conditions and varying.
 - 1.4.2.2.1 Pump operation.
 - 1.4.2.2.2 Boiler and/or chiller operation.
 - 1.4.2.2.3 Pressure bypass open/closed.
 - 1.4.2.2.4 Control pressure failure.
 - 1.4.2.2.5 Maximum heating demand.
 - 1.4.2.2.6 Maximum cooling demand.
 - 1.4.2.2.7 Boiler and/or chiller failure.
 - 1.4.2.2.8 Cooling tower (and/or industrial fluid cooler) fan failure.
 - 1.4.2.2.9 Outdoor reset. Re-check heat exchanger output supply temperature at 100% and 50% reset, maximum water temperature.

1.5 HYDRONIC SYSTEM CAPACITY TEST

- 1.5.1 Timing: After:
 - 1.5.1.1 TAB has been completed
 - 1.5.1.2 Verification of operating, limit, safety controls.
 - 1.5.1.3 Verification of primary and secondary pump flow rates.
 - 1.5.1.4 Verification of accuracy of temperature and pressure sensors and gauges.
- 1.5.2 Calculate system capacity at test conditions.
- 1.5.3 Using manufacturer's published data and calculated capacity at test conditions, extrapolate system capacity at design conditions.
- 1.5.4 When capacity test is completed, return controls and equipment status to normal operating conditions.
- 1.5.5 Submit sample of system water to approved testing agency to determine if chemical treatment is correct. Include cost.
- 1.5.6 Heating system capacity test:
 - 1.5.6.1 Perform capacity test when ambient temperature is within 10% of design conditions. Simulate design conditions by:

- 1.5.6.1.1 Increasing OA flow rates through heating coils (in this case, monitor heating coil discharge temperatures at all times to ensure that coils are not subjected to freezing conditions) or
- 1.5.6.1.2 Reducing space temperature by turning off heating system for sufficient period of time before starting testing.
- 1.5.6.2 Test procedures:
 - 1.5.6.2.1 Open fully heat exchanger, heating coil and radiation control valves.
 - 1.5.6.2.2 With boilers on full firing and hot water heating supply temperature stabilized, record flow rates and supply and return temperatures simultaneously.
 - 1.5.6.2.3 Conduct flue gas analysis test on boilers at full load and at low fire conditions.
- 1.5.7 Chilled water system capacity test:
 - 1.5.7.1 Perform capacity test when ambient temperature is within 10% of design conditions. Simulate design conditions by:
 - 1.5.7.1.1 Adding heat from building heating system or
 - 1.5.7.1.2 Raising space temperature by turning off cooling and air systems for sufficient period of time before starting testing and pre-heating building to summer design space temperature (occupied) or above. Set OAD and RAD for minimum outside air if OAT is near outside design temperature or to maximum recirculation if RAT is greater than OAT. RAT to be at least 23°C.
 - 1.5.7.2 Test procedures:
 - 1.5.7.2.1 Open fully cooling coil control valves.
 - 1.5.7.2.2 Set thermostats on associated AHU's for maximum cooling.
 - 1.5.7.2.3 Set AHU's for design maximum air flow rates.
 - 1.5.7.2.4 Set load or demand limiters on chillers to 100%
 - 1.5.7.2.5 After system has stabilized, record chilled water, condenser water, etc., flow rates and supply and return temperatures simultaneously.
- 1.6 CONDENSER WATER AND HUMIDIFICATION SYSTEMS
 - 1.6.1 In addition to procedures specified above, perform following:
 - 1.6.1.1 Add chemicals once or twice per week as required.
 - 1.6.1.2 Perform TAB as specified Section 23 05 93 - Testing, Adjusting and Balancing for HVAC.
 - 1.6.1.3 Set up and adjust drip feeders, timer controls, and pump strokes as required to maintain required chemical feed rates.
 - 1.6.1.4 Inject inhibitor into cooling tower sump.
- 1.7 STEAM SYSTEMS
 - 1.7.1 Performance verification:
 - 1.7.1.1 When systems are operational, perform relevant tests of steam and condensate return piping systems as specified under hydronic systems.
 - 1.7.1.2 Verify operation of components of steam system including:
 - 1.7.1.2.1 Steam traps by:
 - 1.7.1.2.1.1 Measuring temperature of condensate return and/or using audio-sensing devices.
 - 1.7.1.2.1.2 Use of other approved methods.
 - 1.7.1.2.2 Flash tanks.
 - 1.7.1.2.3 Thermostatic vents.
 - 1.7.1.3 Verify performance of condensation units, including:

- 1.7.1.3.1 Pump capacity at design temperature.
 - 1.7.1.3.2 Controls.
 - 1.7.1.4 Verify performance of condensate return system to ensure return of maximum quantity of condensate return water at with minimum temperature drop.
 - 1.7.1.5 Adjust piping system as required to eliminate water hammer.
- 1.7.2 Monitor system continuously until acceptance for proper operation components including steam traps, thermostatic vents, flash tanks and condensate pumping units.
- 1.8 GLYCOL SYSTEMS
 - 1.8.1 Test to prove concentration will prevent freezing to minus 40°C Test inhibitor strength and include in procedural report. Refer to ASTM E202.
- 1.9 FUEL OIL SYSTEMS
 - 1.9.1 Environmental protection systems:
 - 1.9.1.1 Test oil storage tank leakage detection system using manufacturer's recommended procedures.
 - 1.9.1.2 Test spill protection and over-fill protection systems using manufacturer's recommended procedures.
 - 1.9.2 Fuel oil pumps:
 - 1.9.2.1 Check strainers on pump inlet, relief valve on pump outlet with discharge to oil return piping, pressure gauge on strainer inlet, pump inlet and pump discharge.
 - 1.9.2.2 Verify pump performance.
 - 1.9.2.3 Pump performance to be within plus 20% and minus 0% of design.
 - 1.9.3 Operational Tests:
 - 1.9.3.1 Timing: Perform at same time as 100% and 105% boiler PV tests.
 - 1.9.3.2 Charge system and verify operation.
 - 1.9.3.3 Verify adequacy of flow rates and pressure from storage facilities to burners.
 - 1.9.3.4 Verify accurate metering of fuel to burners.
 - 1.9.3.5 For further details refer to relevant sections of mechanical Division.
 - 1.9.4 Notify authorities having jurisdiction to enable witnessing of tests as required.
- 1.10 POTABLE WATER SYSTEMS
 - 1.10.1 When cleaning is completed and system filled:
 - 1.10.1.1 Verify performance of equipment and systems as specified elsewhere in mechanical Division.
 - 1.10.1.2 Check for proper operation of water hammer arrestors. Run one outlet for 10 seconds, then shut of water immediately. If water hammer occurs, replace water hammer arrestor. Repeat for each outlet and flush valve.
 - 1.10.1.3 Confirm water quality consistent with supply standards, verifying that no residuals remain as a result of flushing and/or cleaning.
- 1.11 WET AND DRY PIPE SPRINKLER SYSTEM, STANDPIPE AND HOSE SYSTEMS
 - 1.11.1 Cleaning, testing, start-up, performance verification of equipment, systems, components, and devices is specified elsewhere in other mechanical Divisions.
 - 1.11.2 Verification of controls, detection devices, alarm devices is specified other mechanical and electrical Divisions.
 - 1.11.3 Demonstrate that fire hose will reach to most remote location regardless of partitions, obstructions, etc.

1.11.4 Verify operation of interlocks between HVAC systems and fire alarm systems.

1.12 SANITARY AND STORM DRAINAGE SYSTEMS

1.12.1 Buried systems: Perform tests prior to back-filling. Perform hydraulic tests to verify grades and freedom from obstructions.

1.12.2 Ensure that traps are fully and permanently primed.

1.12.3 Ensure that fixtures are properly anchored, connected to system.

1.12.4 Operate flush valves, tank and operate each fixture to verify drainage and no leakage.

1.12.5 Cleanouts: Refer to Section 22 05 15 - Plumbing Specialties and Accessories.

1.12.6 Roof drains:

1.12.6.1 Refer to Section 22 05 15 - Plumbing Specialties and Accessories.

1.12.6.2 Remove caps as required.

1.13 REPORTS

1.13.1 In accordance with Section 01 91 13.13 -Commissioning (Cx) Requirements: supplemented as specified herein.

1.14 TRAINING

1.14.1.1 In accordance with Section 01 91 13.13 -Commissioning (Cx) Requirements: supplemented as specified in relevant specification sections

PART 2 PRODUCTS (NOT APPLICABLE)

PART 3 EXECUTION (NOT APPLICABLE)

END OF SECTION

SECTION 232300:

REFRIGERANT PIPING

1. PART 1 GENERAL

1.1 SUMMARY

1.1.1 Section Includes:

1.1.1.1 Materials and installation for copper tubing and fittings for refrigerant.

1.2 RELATED SECTIONS:

1.2.1 Section 01 33 00 - Submittal Procedures.

1.2.2 Section 01 74 21 - Construction/Demolition Waste Management and Disposal.

1.2.3 Section 01 78 00 - Closeout Submittals.

1.2.4 Section 23 05 15 - Common Installation Requirements for HVAC Pipework.

1.3 REFERENCES

1.3.1 American Society of Mechanical Engineers (ASME)

1.3.1.1 ASME B16.22, Wrought Copper and Copper Alloy Solder - Joint Pressure Fittings.

1.3.1.2 ASTM A307, Standard Specification for Carbon Steel Bolts and Studs, and Threaded Rod 60,000 PSI Tensile Strength.

1.3.1.3 ASME B16.26, Cast Copper Alloy Fittings for Flared Copper Tubes.

1.3.1.4 ASME B31.5, Refrigeration Piping and Heat Transfer Components.

1.3.2 American Society for Testing and Materials (ASTM)

1.3.2.1 ASTM A 307, Standard Specification for Carbon Steel Bolts and Studs, 60,000 PSI Tensile Strength.

1.3.2.2 ASTM B 280, Standard Specification for Seamless Copper Tube for Air Conditioning and Refrigeration Field Service.

1.3.3 Canadian Standards Association (CSA)

1.3.3.1 CSA B52, Mechanical Refrigeration Code.

1.3.4 Environment Canada (EC)

1.3.4.1 EPS1/RA/1, Environmental Code of Practice for the Elimination of Fluorocarbon Emissions from Refrigeration and Air Conditioning Systems.

1.3.5 Province of Newfoundland and Labrador Boiler, Pressure Vessel and Compressed Gas Regulations

1.4 SUBMITTALS

1.4.1 Submittals in accordance with Section 01 33 00 - Submittal Procedures.

1.4.2 Test Reports: submit certified test reports from approved independent testing laboratories indicating compliance with specifications for specified

performance characteristics and physical properties.

1.4.3 Certificates: submit certificates signed by manufacturer certifying that materials comply with specified performance characteristics and physical properties.

1.4.4 Instructions: submit manufacturer's installation instructions.

1.4.5 Closeout submittals: submit maintenance and engineering data for incorporation into manual specified in Section 01 78 00 - Closeout Submittals.

1.5 QUALITY ASSURANCE

1.5.1 Pre-Installation Meeting:

1.5.1.1 Convene pre-installation meeting one week prior to beginning work of this Section and on-site installations.

1.5.1.1.1 Verify project requirements.

1.5.1.1.2 Review installation and substrate conditions.

1.5.1.1.3 Co-ordination with other building subtrades.

1.5.1.1.4 Review manufacturer's installation instructions and warranty requirements.

1.5.2 Health and Safety:

1.5.2.1 Do construction occupational health and safety in accordance with Safety Requirements.

1.5.3 Trades people to be journeyperson and graduate from a recognized college refrigeration trade program.

1.6 DELIVERY, STORAGE AND HANDLING

1.6.1 Waste Management and Disposal:

1.6.1.1 Separate waste materials for reuse and recycling in accordance with Section 01 74 21 - Construction/Demolition Waste Management and Disposal.

1.6.1.2 Remove from site and dispose of packaging materials at appropriate recycling facilities.

1.6.1.3 Collect and separate for disposal, paper, plastic, polystyrene, corrugated cardboard packaging material in appropriate on-site bins for recycling in accordance with Waste Management Plan (WMP).

1.6.1.4 Separate for reuse and recycling and place in designated containers, steel, metal, plastic waste in accordance with Waste Management Plan (WMP).

1.6.1.5 Divert unused metal materials from landfill to metal recycling facility as approved by Owner.

2. PART 2 PRODUCTS

2.1 TUBING

2.1.1 Processed for refrigeration installations, deoxidized, dehydrated and sealed.

2.1.1.1 Hard copper: to ASTM B280, type ACR B (nitrogenized).

2.1.1.2 Annealed copper: to ASTM B280, with minimum wall thickness as per CSA B52 and ASME B31.5.

2.2 FITTINGS

2.2.1 Service: design pressure 2070 kPa and temperature 121° C.

2.2.2 Brazed:

2.2.2.1 Fittings: wrought copper to ASME B16.22.

2.2.2.2 Joints: silver solder, 45% Ag - 80% Cu - 5% P and non-corrosive flux for copper to steel or brass; Silfoss-15 for copper to copper.

2.2.3 Flanged:

2.2.3.1 Bronze or brass, to ASME B16.24, Class 150 and Class 300, tongue and groove type.

- 2.2.3.2 Gaskets: suitable for service.
- 2.2.3.3 Bolts, nuts and washers: to ASTM A307, heavy series.
- 2.2.4 Flared:
 - 2.2.4.1 Bronze or brass, for refrigeration, to ASME B16.26.
- 2.3 PIPE SLEEVES
 - 2.3.1 Hard copper or steel, sized to provide 6.0 mm clearance between sleeve and uninsulated pipe or between sleeve and insulation.
- 2.4 VALVES
 - 2.4.1 7/8 ODS and under: Class 500, 3.5 MPa, globe or angle non-directional type, diaphragm, packless type, with forged brass body and bonnet, moisture proof seal for below freezing applications, brazed connections.
 - 2.4.2 Over 7/8 ODS: Class 375, 3 MPa, globe or angle type, diaphragm, packless type, back-seating, cap seal, with cast bronze body and forged brass bonnet, moisture-proof seal for below freezing applications, brazed connections, non-rotating, self-aligning swivel disc, Teflon seat, -40° C - 163° C.
 - 2.4.3 Ball valves 7 3/8 ODS to 3 1/8 ODS: maximum WP 4MPa, -40° C to 149° C, live loaded stem seal, double "O" ring hermetically sealed body, blowout proof stem, seal cap "O" ring sealed, valve position indicators, forged brass body bonnet, brass cap, triple sealed plated steel item, Teflon ball seals and gasket, extended copper connections, helium leak test to maximum 0.28 g/yr.
 - 2.4.4 Check valves 7/8 ODS to 3 1/8 ODS cast bronze body, brass bonnet, Teflon seat, internal parts removable minimum opening pressure 3.5 kPa, maximum WP 3.5 kPa - 29° C to 149° C, UL and CSA approved.
 - 2.4.5 Check valves 3/8 ODS to 7/8 ODS: brass construction, Teflon seal, removable piston, maximum WP 3.5 kPa, -40° C to 149° C, suitable for high side, low side and hot gas. UL and CSA approved, maximum opening pressure 3.5 kPa.
- 3. PART 3 EXECUTION
 - 3.1 MANUFACTURER'S INSTRUCTIONS
 - 3.1.1 Compliance: comply with manufacturer's written recommendations or specifications, including product technical bulletins, handling, storage and installation instructions, and datasheet.
 - 3.2 GENERAL
 - 3.2.1 In accordance with Section 23 05 15 - Common Installation Requirements for HVAC PIPework, supplemented as specified herein.
 - 3.2.2 Install in accordance with CSA B52, EPS1/RA/1 and ASME B31.5.
 - 3.3 BRAZING PROCEDURES
 - 3.3.1 Bleed inert gas into pipe during brazing.
 - 3.3.2 Remove valve internal parts, solenoid valve coils, sight glass.
 - 3.3.3 Do not apply heat near expansion valve and bulb.
 - 3.4 PIPING INSTALLATION
 - 3.4.1 General:
 - 3.4.1.1 Soft annealed copper tubing: bend without crimping or constriction, hard drawn copper tubing: do not bend. Minimize use of fittings.
 - 3.4.1.2 Hot gas lines:
 - 3.4.1.2.1 Pitch at least 1:240 down in direction of flow to prevent oil return to compressor during operation.
 - 3.4.1.2.2 Provide trap at base of risers greater than 1800 mm high and at each 6000 mm thereafter.
 - 3.4.1.2.3 Provide inverted deep trap at top of risers.

- 3.4.1.2.4 Provide double risers for compressors having capacity modulation.
- 3.4.1.2.4.1 Large riser: install traps as specified above.
- 3.4.1.2.4.2 Small riser: size for 5.1 m/s at minimum load. Connect upstream of traps on large riser.
- 3.5 PRESSURE AND LEAK TESTING
 - 3.5.1 Close valves on factory charged equipment and other equipment not designed for test pressures.
 - 3.5.2 Leak test to CSA B52 before evacuation to 2 MPa and 1 MPa on high and low sides respectively.
 - 3.5.3 Test Procedure: Build pressure up to 35 kPa using nitrogen leave for 8 hours.
- 3.6 FIELD QUALITY CONTROL
 - 3.6.1 Site Tests/Inspection
 - 3.6.1.1 Close service valves on factory charged equipment.
 - 3.6.2 Ambient temperatures to be at least 13 degrees C for at least 12 hours before and during dehydration.
 - 3.6.3 Use copper lines for largest practical size to reduce evacuation time.
 - 3.6.4 Use two-stage vacuum pump with gas ballast on 2nd stage capable of pulling 5 Pa absolute and filled with dehydrated oil.
 - 3.6.5 Measure system pressure with vacuum gauge. Take readings with valve between vacuum pump and system closed.
 - 3.6.6 Triple evacuate system components containing gases other than correct refrigerant or having lost holding charge as follows:
 - 3.6.6.1 Twice to 14 Pa absolute and hold for 4 h.
 - 3.6.6.2 Break vacuum with refrigerant to 14 KPa.
 - 3.6.6.3 Final to 5 Pa absolute and hold for at least 12 h.
 - 3.6.6.4 Isolate pump from system, record vacuum and time readings until stabilization of vacuum.
 - 3.6.6.5 Submit test results to Owner.
 - 3.6.7 Charging:
 - 3.6.7.1 Charge system through filter-drier and charging valve on high side. Low side charging not permitted.
 - 3.6.7.2 With compressors off, charge only amount necessary for proper operation of system. If system pressures equalize before system is fully charged, close charging valve and start up. With unit operating, add remainder of charge to system.
 - 3.6.7.3 Re-purge charging line if refrigerant container is changed during charging process.
 - 3.6.8 Checks:
 - 3.6.8.1 Make checks and measurements as per manufacturer's operation and maintenance instructions.
 - 3.6.8.2 Record and report measurements to Owner.
 - 3.6.9 Manufacturer's Field Services:
 - 3.6.9.1 Have manufacturer of products, supplied under this Section, review work involved in the handling, installation/application, and protection and cleaning, of its products and submit written reports, in acceptable format, to verify compliance of work with Contract.
 - 3.6.9.2 Provide manufacturer's field services consisting of product use recommendations and periodic site visits for inspection of product installation in accordance with manufacturer's instructions.
 - 3.6.9.3 Schedule site visits, to review work, at stages listed:

- 3.6.9.3.1 After delivery and storage of products, and when preparatory work, or other work, on which the work of this Section depends, is complete but before installation begins.
- 3.6.9.3.2 Twice during progress of work at 25% and 60% complete.
- 3.6.9.3.3 Upon completion of the work, after cleaning is carried out.
- 3.6.9.4 Obtain reports, within three (3) working days of review, and submit, immediately, to Owner.

3.7 DEMONSTRATION**3.7.1 Instructions:**

- 3.7.1.1 Post instructions in frame with glass cover in accordance with Section 01 78 00 – Closeout Submittals and CSA B52.
 - 3.7.1.1.1 Perform cleaning operations as specified in Section 01 74 00 – Cleaning and in accordance with manufacturer's recommendations.
 - 3.7.1.1.2 On completion and verification of performance of installation, remove surplus materials, excess materials, rubbish, tools and equipment.

END OF SECTION**SECTION 233248:****ACOUSTICAL AIR PLENUMS****1. PART 1 GENERAL****1.1 SUMMARY****1.1.1 Section includes:**

- 1.1.1.1 Materials and performance criteria for sound attenuation for mechanical systems.

1.2 RELATED SECTIONS

- 1.2.1 Section 01 33 00 – Submittal Procedures.
- 1.2.2 Section 01 74 21 – Construction/Demolition Waste Management and Disposal.
- 1.2.3 Section 23 05 93 – Testing, Adjusting and Balancing for HVAC.

1.3 REFERENCES

- 1.3.1 American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE)
- 1.3.2 American Society for Testing and Materials International (ASTM)

- 1.3.2.1 ASTM A 653/A653M, Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process.
- 1.3.2.2 ASTM C 423, Standard Test Method for Sound Absorption and Sound Absorption Coefficients by the Reverberation Room Method.
- 1.3.2.3 ASTM E 90, Standard Test Method for Laboratory Measurement of Airborne Sound Transmission Loss of Building Partitions and Elements.
- 1.3.2.4 ASTM E 477, Test Method for Measuring Acoustical and Airflow Performance of Duct Liner Materials and Prefabricated Silencers.
- 1.3.3 National Building Code (NBC).
- 1.3.4 Sheet Metal and Air Conditioning Contractors' National Association (SMACNA)
- 1.4 SUBMITTALS
 - 1.4.1 Product Data:
 - 1.4.1.1 Submit manufacturer's printed product literature, specifications and datasheet in accordance with Section 01 33 00 – Submittal Procedures. Include product characteristics, performance criteria, and limitations.
 - 1.4.1.1.1 Submit two copies of Workplace Hazardous Materials Information System (WHMIS) Safety Data Sheets (SDS) in accordance with Section 01 33 00 – Submittal Procedures.
 - 1.4.2 Shop Drawings:
 - 1.4.2.1 Submit Shop drawings in accordance with Section 01 33 00 – Submittal Procedures.
 - 1.4.2.2 Provide separate shop drawings for each piece of attenuation equipment, system shop drawings complete with product data.
 - 1.4.3 Quality assurance submittals: submit following in accordance with Section 01 33 00 – Submittal Procedures.
 - 1.4.3.1 Certificates: Submit certificates signed by manufacturer certifying that materials comply with specified performance characteristics and physical properties.
 - 1.4.3.2 Instructions: submit manufacturer's installation instructions.
- 1.5 PERFORMANCE REQUIREMENTS
 - 1.5.1 Rating Data:
 - 1.5.1.1 Provide performance rating data, certified by professional engineer or accredited test laboratory and supported by calculations and verified by test results in accordance with referenced standards as follows:
 - 1.5.1.1.1 Silencer: insertion loss, pressure drop at design conditions, generated noise level.
 - 1.5.1.1.2 Acoustic plenums: transmission loss and acoustical absorption.
 - 1.5.1.1.3 Acoustical performance measurements in accordance with ASTM E 477, ASTM E 90 and ASTM C 423, except where specified otherwise.
- 1.6 QUALITY ASSURANCE
 - 1.6.1 Health and Safety Requirements: do construction occupational health and safety in accordance with Health and Safety Requirements.
- 1.7 DELIVERY, STORAGE, AND HANDLING
 - 1.7.1 Packing, shipping, handling, and unloading:
 - 1.7.1.1 Deliver, store, and handle in accordance with manufacturer's written instructions and Section 01 61 00 – Common Product Requirements.
 - 1.7.1.2 Deliver, store and handle materials in accordance with manufacturer's written instructions.

1.7.2 Waste Management and Disposal:

- 1.7.2.1 Construction/Demolition Waste Management and Disposal: separate waste materials for reuse and recycling in accordance with Section 01 74 21 – Construction/Demolition Waste Management and Disposal.

2. PART 2 PRODUCTS

2.1 ABSORPTION AND INSULATING MEDIA

- 2.1.1 Acoustic quality, glass fibre, free of shot and odour; bacteria and fungus resistant; free of corrosion causing or accelerating agents; packed to density to meet performance requirements; and meet NBC fire requirements or requirements of authority having jurisdiction for duct lining.

2.2 SILENCERS

- 2.2.1 Factory manufactured of prime coated or galvanized steel, compatible with ductwork specified elsewhere and to ASHRAE and SMACNA standards.
- 2.2.2 Outer casing and galvanized steel inner casing with clean cut circular perforations to enclose acoustic media. Inner casing to have half-splitters running full length of silencer where any cross sectional dimension exceeds 450 mm. Protect media from erosion with tedlar or mylar between media and perforated metal.
- 2.2.3 Performance: see silencer schedule.

2.3 ACOUSTIC PLENUMS

- 2.3.1 Panels: tongue and groove connection type, designed for individual panel removal for equipment access without major dismantling of plenum.
 - 2.3.1.1 Outer sheet: 1.3 mm thick galvanized steel to ASTM A653/A653M, with coating designation G90 (Exposed to outside air).
 - 2.3.1.2 Inner sheet: 0.85 mm thick galvanized steel to ASTM A653/A653M, with coating designation G90 with 2.0 mm diameter clean cut perforations on 5.0 mm staggered centres.
 - 2.3.1.3 Fully framed with 1.3 mm thick galvanized steel channels.
 - 2.3.1.4 Horizontal stiffeners: 0.85 mm minimum galvanized steel on 800 mm centres to control media settlement.
 - 2.3.1.5 Access panels: sized for equipment removal; two handles per panel; screw at 100 mm maximum centres; perimeter neoprene sponge gasket; materials same as standard panel.
 - 2.3.1.6 Deflection: not to exceed 1/240 of unsupported panel span at design pressure differential of 500 Pa.
 - 2.3.1.7 Connections: acoustically sealed.
- 2.3.2 Doors: access doors with minimum 510 x 1375 mm opening.
 - 2.3.2.1 Construction same as standard panel except interiors to be solid.
 - 2.3.2.2 Two butt-type nylon bushed hinges, two cam-type latches with inside and outside handles.
 - 2.3.2.3 Neoprene gasket seal.
 - 2.3.2.4 Zinc plated hardware.
 - 2.3.2.5 Open against air pressure.
- 2.3.3 Windows: inspection windows, 305 x 305 mm, double glazed with 6 mm wire reinforced glass mounted in neoprene "U" channels.
- 2.3.4 Assembly: base sections and flashings 1.3 mm minimum galvanized steel.
 - 2.3.4.1 Panel and flashing joints externally sealed with 5 mm diameter bead of non sag, non-hardening sealant. Floor channel to floor connection sealed with 3.0 x 13 mm monolastomeric tape.
 - 2.3.4.2 Factory cut and frame openings where greatest dimension exceeds 300 mm. Smaller panel openings, to be site located and cut 50 mm larger in diameter, sleeved with 0.75 mm minimum galvanized steel.

- 2.3.4.3 Fill space between pipe or conduit and sleeve with acoustic media, covered and mastic sealed in accordance with manufacturer's instructions.
- 2.3.4.4 No sensory leakage at design pressure differential of 500 Pa.
- 2.3.4.5 Assembly RSI not less than 1.2 (m².°C)/W at 10°C.
- 2.3.4.6 Certified acoustical performance:
 - 2.3.4.6.1 Transmission loss to ASTM E90.
 - 2.3.4.6.2 Acoustical absorption to ASTM C423.
- 2.3.5 Tubing tail sample water connections of ¼ OD.
- 2.3.6 NPT ½ female connections for coolant water.
- 3. PART 3 EXECUTION
- 3.1 MANUFACTURER'S INSTRUCTIONS
 - 3.1.1 Compliance: comply with manufacturer's written recommendations or specifications, including product technical bulletins, handling, storage and installation instructions, and datasheet.
- 3.2 INSTALLATION
 - 3.2.1 Noise flanking: where indicated, install in wall sleeve with uniform clearance around to ensure no contact of silencer with wall sleeve. Pack with flexible, non hardening caulking on both sides of sleeves.
 - 3.2.2 Instrument test ports: install at inlet and outlet to permit measurement of insertion loss and pressure loss.
 - 3.2.3 Suspension: to manufacturer's instructions.
- 3.3 FIELD QUALITY CONTROL
 - 3.3.1 Testing:
 - 3.3.1.1 Experienced and competent sound and vibration testing professional engineer to take sound measurement after start up and testing, adjusting and balancing of systems to Section 23 05 93 - Testing, Adjusting and Balancing for HVAC.
 - 3.3.1.2 Sound measurements to extend over frequency range of 125 to 4000 Hz and taken:
 - 3.3.1.2.1 Upstream and downstream of each silencer and plenum
 - 3.3.1.2.2 In areas adjacent to mechanical equipment rooms, duct and pipe shafts.
 - 3.3.1.2.3 At 1800 mm above floor adjacent to first air terminal.
 - 3.3.1.2.4 At following critical locations: air handling units, chillers, pumps, fans, air compressors, refrigeration compressors.
 - 3.3.1.3 Provide Owner with notice two (2) working days in advance of commencement of tests.
 - 3.3.1.4 Establish adequacy of equipment isolation, acceptability of noise levels in occupied areas, other conditions affecting acoustics and, where appropriate, recommendation for remedial measures and costs.
 - 3.3.1.5 Submit complete report of test results including sound curves. Include in Commissioning Manual.
 - 3.3.2 Manufacturer's Field Services:
 - 3.3.2.1 Arrange with manufacturer's representative to review work of this Section and submit written reports to verify compliance with Contract Documents.
 - 3.3.2.2 Manufacturer's Field Services: consisting of product use recommendations and periodic site visits to review installation, scheduled as follows:
 - 3.3.2.2.1 After delivery and storage of products.

3.3.2.2.2 After preparatory work is complete but before installation commences.

3.3.2.2.3 Twice during the installation, at 25 % and 60 % completion stages.

3.3.2.2.4 Upon completion of installation.

3.3.2.3 Submit manufacturer's reports to Owner within three (3) working days of manufacturer representative's review.

3.4 ADJUSTING

3.4.1 Make adjustments and corrections in accordance with written report.

3.4.2 Provide Owner with notice two (2) working days in advance of visit.

3.5 CLEANING

3.5.1 Proceed in accordance with Section 01 74 00 – Cleaning.

3.5.2 Upon completion and verification of performance of installation, remove surplus materials, excess materials, rubbish, tools and equipment.

END OF SECTION

SECTION 233300:**AIR DUCT ACCESSORIES****1. PART 1 GENERAL****1.1 SUMMARY****1.1.1 Section Includes:**

- 1.1.1.1 Materials and installation for duct accessories including flexible connections, access doors, vanes and collars.

1.2 RELATED SECTIONS

- 1.2.1 Section 01 33 00 – Submittal Procedures.
- 1.2.2 Section 01 45 00 – Quality Control.
- 1.2.3 Section 01 74 21 – Construction/Demolition Waste Management and Disposal.
- 1.2.4 Section 01 78 00 – Closeout Submittals.

1.3 REFERENCES

- 1.3.1 Sheet Metal and Air Conditioning Contractors' National Association (SMACNA).
 - 1.3.1.1 SMACNA – HVAC Duct Construction Standards – Metal and Flexible.

1.4 SUBMITTALS

- 1.4.1 Submittals in accordance with Section 01 33 00 – Submittal Procedures.
- 1.4.2 Product Data:
 - 1.4.2.1 Submit manufacturer's printed product literature, specifications and data sheet. Indicate the following:
 - 1.4.2.1.1 Flexible connections
 - 1.4.2.1.2 Duct access doors.
 - 1.4.2.1.3 Turning vanes.
 - 1.4.2.1.4 Instrument test ports.
 - 1.4.2.2 Submit WHMIS SDS in accordance with Section 01 33 00 - Submittal Procedures. Indicate VOC's for adhesive and solvents during application and curing.
- 1.4.3 Test Reports: submit certified test reports from approved independent testing laboratories indicating compliance with specifications for specified performance characteristics and physical properties.
 - 1.4.3.1 Certification of ratings: catalogue or published ratings to be those obtained from tests carried out by manufacturer or independent testing agency signifying adherence to codes and standards.
- 1.4.4 Certificates: submit certificates signed by manufacturer certifying that materials comply with specified performance characteristics and physical properties.
- 1.4.5 Instructions: submit manufacturer's installation instructions.
- 1.4.6 Manufacturer's Field Reports: manufacturer's field reports specified.
- 1.4.7 Closeout Submittals: submit maintenance and engineering data for incorporation into manual specified in Section 01 78 00 – Closeout Submittals.

1.5 QUALITY ASSURANCE

- 1.5.1 Pre-Installation Meetings:
 - 1.5.1.1 Convene pre-installation meeting one week prior to beginning work of this Section and on-site installations.
 - 1.5.1.1.1 Verify project requirements.
 - 1.5.1.1.2 Review installation and substrate conditions.
 - 1.5.1.1.3 Co-ordination with other building subtrades.

- 1.5.1.1.4 Review manufacturer's installation instructions and warranty requirements.
- 1.5.1.2 Health and Safety:
 - 1.5.1.2.1 Do construction occupational health and safety in accordance with Health and Safety Requirements.
- 1.6 DELIVERY, STORAGE AND HANDLING
 - 1.6.1 Waste Management and Disposal:
 - 1.6.1.1 Separate waste materials for reuse and recycling in accordance with Section 01 74 21 - Construction/Demolition Waste Management and Disposal.
 - 1.6.1.2 Remove from site and dispose of packaging materials at appropriate recycling facilities.
 - 1.6.1.3 Collect and separate for disposal paper, plastic, polystyrene, and corrugated cardboard, packaging material in appropriate on-site bins for recycling in accordance with Waste Management Plan (WMP).
 - 1.6.1.4 Separate for reuse and recycling and place in designated containers steel, metal, and plastic waste in accordance with Waste Management Plan (WMP).
 - 1.6.1.5 Divert unused metal materials from landfill to metal recycling facility as approved by Owner.
- 2. PART 2 PRODUCTS
 - 2.1 GENERAL
 - 2.1.1 Manufacture in accordance with SMACNA - HVAC Duct Construction Standards.
 - 2.2 FLEXIBLE CONNECTIONS
 - 2.2.1 Frame: galvanized sheet metal frame 0.66 mm thick with fabric clenched by means of double locked seams.
 - 2.2.2 Material:
 - 2.2.2.1 Fire resistant, self extinguishing, neoprene coated glass fabric, temperature rated at minus 40°C to plus 90°C, density of 1.3 kg/m².
 - 2.3 ACCESS DOORS IN DUCTS
 - 2.3.1 Non-insulated ducts: sandwich construction of same material as duct, one sheet metal thickness heavier, minimum 0.6 mm thick complete with sheet metal angle frame.
 - 2.3.2 Insulated ducts: sandwich construction of same material as duct, one sheet metal thickness heavier, minimum 0.6 mm thick complete with sheet metal angle frame and 25 mm thick rigid glass fibre insulation.
 - 2.3.3 Gaskets: neoprene.
 - 2.3.4 Hardware:
 - 2.3.4.1 Hold open devices.
 - 2.3.4.2 300 x 300 mm glass viewing panels.
 - 2.3.4.3 Up to 300 x 300 mm: two sash locks complete with safety chain.
 - 2.3.4.4 301 to 450 mm: four sash locks complete with safety chain.
 - 2.3.4.5 451 to 1000 mm: piano hinge and minimum two sash locks.
 - 2.3.4.6 Doors over 1000 mm: piano hinge and two handles operable from both sides.
 - 2.3.4.6.1 Hold open devices.
 - 2.3.4.6.2 300 X 300 mm glass viewing panels.
 - 2.4 TURNING VANES
 - 2.4.1 Factory or shop fabricated double thickness with trailing edge, to recommendations of SMACNA and as indicated.

2.5 INSTRUMENT TEST PORTS

1.7 mm thick steel zinc plated after manufacture.

- 2.5.1 Cam lock handles with neoprene expansion plug and handle chain.
- 2.5.2 28 mm minimum inside diameter. Length to suit insulation thickness.
- 2.5.3 Neoprene mounting gasket.

2.6 SPIN-IN COLLARS

- 2.6.1 Conical galvanized sheet metal spin-in collars with lockable butterfly damper.
- 2.6.2 Sheet metal thickness to co-responding round duct standards.

3. PART 3 EXECUTION

3.1 MANUFACTURER'S INSTRUCTIONS

- 3.1.1 Compliance: comply with manufacturer's written recommendations or specifications, including product technical bulletins, handling, storage and installation instructions, and datasheet.

3.2 INSTALLATION

3.2.1 Flexible connections:

3.2.1.1 Install in following locations:

- 3.2.1.1.1 Inlets and outlets to supply air units and fans.
- 3.2.1.1.2 Inlets and outlets of exhaust and return air fans.
- 3.2.1.1.3 As indicated.

3.2.1.2 Length of connection: 100 mm.

3.2.1.3 Minimum distance between metal parts when system in operation: 75 mm.

3.2.1.4 Install in accordance with recommendations of SMACNA.

3.2.1.5 When fan is running:

- 3.2.1.5.1 Ducting on sides of flexible connection to be in alignment.
- 3.2.1.5.2 Ensure slack material in flexible connection.

3.2.2 Access doors and viewing panels:

3.2.2.1 Size:

- 3.2.2.1.1 600 x 600 mm for person size entry.
- 3.2.2.1.2 450 x 450 mm for servicing entry.
- 3.2.2.1.3 300 x 300 mm for viewing.
- 3.2.2.1.4 As indicated.

3.2.2.2 Locations:

- 3.2.2.2.1 Fire and smoke dampers.
- 3.2.2.2.2 Control dampers.
- 3.2.2.2.3 Devices requiring maintenance.
- 3.2.2.2.4 Required by code.
- 3.2.2.2.5 Reheat coils.
- 3.2.2.2.6 Elsewhere as indicated.

3.2.3 Instrument test ports.

3.2.3.1 General:

- 3.2.3.1.1 Install in accordance with recommendations of SMACNA and in accordance with manufacturer's instructions.

3.2.3.2 Locate to permit easy manipulation of instruments.

3.2.3.3 Install insulation port extensions as required.

3.2.3.4 Locations.

3.2.3.4.1 For traverse readings:

- 3.2.3.4.1.1 Ducted inlets to roof and wall exhausters.
- 3.2.3.4.1.2 Inlets and outlets of other fan systems.
- 3.2.3.4.1.3 Main and sub-main ducts.
- 3.2.3.4.1.4 And as indicated.

- 3.2.3.4.2 For temperature readings:
 - 3.2.3.4.2.1 At outside air intakes.
 - 3.2.3.4.2.2 In mixed air applications in locations as approved by Owner.
 - 3.2.3.4.2.3 At inlet and outlet of coils.
 - 3.2.3.4.2.4 Downstream of junctions of two converging air streams of different temperatures.
 - 3.2.3.4.2.5 And as indicated.
- 3.2.4 Turning vanes:
 - 3.2.4.1 Install in accordance with recommendations of SMACNA and as indicated.
- 3.3 FIELD QUALITY CONTROL
 - 3.3.1 Manufacturer's Field Services:
 - 3.3.1.1 Have manufacturer's representative of products, supplied under this Section, review Work involved in the handling, installation/application, protection and cleaning, of its products and submit written reports, in acceptable format, to verify compliance of Work with Contract.
 - 3.3.1.2 Manufacturer's Field Services: provide manufacturer's field services consisting of product use recommendations and periodic site visits for inspection of product installation in accordance with manufacturer's instructions.
 - 3.3.1.3 Schedule site visits, to review Work, at stages listed:
 - 3.3.1.3.1 After delivery and storage of products, and when preparatory Work, or other Work, on which the Work of this Section depends, is complete but before installation begins.
 - 3.3.1.3.2 Twice during progress of Work at 25% and 60% complete.
 - 3.3.1.3.3 Upon completion of the Work, after cleaning is carried out.
 - 3.3.1.4 Obtain reports, within three (3) working days of review, and submit, immediately, to Owner.
- 3.4 CLEANING
 - 3.4.1 Perform cleaning operations as specified in Section 01 74 00 – Cleaning and in accordance with Manufacturer's recommendations.
 - 3.4.2 Upon completion and verification of performance of installation, remove surplus materials, excess materials, rubbish, tools and equipment.

END OF SECTION

SECTION 233314:**DAMPERS-BALANCING****1. PART 1 GENERAL****1.4 SUMMARY****1.4.2 Section Includes:**

4. Balancing dampers for mechanical forced air ventilation and air conditioning systems.

1.5 RELATED SECTIONS:

- 1.5.2 Section 01 33 00 – Submittal Procedures.
- 1.5.3 Section 01 45 00 – Quality Control.
- 1.5.4 Section 01 74 21 – Construction/Demolition Waste Management and Disposal.
- 1.5.5 Section 01 78 00 – Closeout Submittals.

1.6 REFERENCES

- 1.6.2 Sheet Metal and Air Conditioning National Association (SMACNA)
 4. SMACNA HVAC Duct Construction Standards, Metal and Flexible.

1.7 SUBMITTALS**1.7.2 Product Data:**

4. Submit manufacturer's printed product literature, specifications and datasheet in accordance with Section 01 33 00 – Submittal Procedures. Include product characteristics, performance criteria, and limitations.

- 1.7.2.4.1 Submit two copies of Workplace Hazardous Materials Information System (WHMIS) Safety Data Sheets (SDS) in accordance with Section 01 33 00 – Submittal Procedures.

1.7.2.4.2 Indicate the following:**1.7.2.4.2.1 Specifications.**

5. Quality assurance submittals: submit following in accordance with Section 01 33 00 – Submittal Procedures.

- 1.7.2.5.1 Certificates: Submit certificates signed by manufacturer certifying that materials comply with specified performance characteristics and physical properties.

- 1.7.2.5.2 Instructions: Submit manufacturer's installation instructions.

1.8 QUALITY ASSURANCE**1.8.2 Health and Safety Requirements:**

4. Do construction occupational health and safety in accordance with Health and Safety Requirements.

1.9 DELIVERY, STORAGE, AND HANDLING**1.9.2 Packing, shipping, handling and unloading:**

4. Deliver, store and handle in accordance with Section 01 61 00 – Common Product Requirements.

1.9.3 Waste Management and Disposal:

4. Construction/Demolition Waste Management and Disposal: separate waste materials for reuse and recycling in accordance with Section 01 74 21 – Construction/Demolition Waste Management and Disposal.

2 PART 2 PRODUCTS**2.4 GENERAL**

- 2.4.2 Manufacture to SMACNA standards.

2.5 SINGLE BLADE DAMPERS

- 2.5.2 Fabricate from same material as duct, 0.8 mm up to 450 mm wide, 1.6 mm maximum up to 1200 mm wide, V-groove stiffened.

- 2.5.3 Size and configuration to recommendations of SMACNA, except maximum height 100 mm.
- 2.5.4 Locking quadrant with shaft extension to accommodate insulation thickness.
- 2.5.5 Inside and outside nylon or bronze end bearings.
- 2.5.6 Channel frame of same material as adjacent duct, complete with angle stop.
- 2.6 MULTI-BLADED DAMPERS
 - 2.6.2 Factory manufactured of material compatible with duct.
 - 2.6.3 Opposed blade: configuration, metal thickness and construction to recommendations of SMACNA.
 - 2.6.4 Maximum blade height: 100 mm.
 - 2.6.5 Bearings: pin in bronze bushings or self-lubricating nylon.
 - 2.6.6 Linkage: shaft extension with locking quadrant.
 - 2.6.7 Channel frame of same material as adjacent duct, complete with angle stop.
 - 2.6.8 Maximum leakage: 2 % at 500 Pa.

3 PART 3 EXECUTION

3.4 MANUFACTURER'S INSTRUCTIONS

- 3.4.2 Compliance: comply with manufacturer's written recommendations or specifications, including product technical bulletins, handling, storage and installation instructions, and datasheet.

3.5 INSTALLATION

- 3.5.2 Install where indicated.
- 3.5.3 Install in accordance with recommendations of SMACNA and in accordance with manufacturer's instructions.
- 3.5.4 For supply, return and exhaust systems, locate balancing dampers in each branch duct.
- 3.5.5 Runouts to registers and diffusers: located as close as possible to main ducts.
- 3.5.6 All dampers to be vibration free.
- 3.5.7 Ensure damper operators are observable and accessible.

3.6 CLEANING

- 3.6.2 Proceed in accordance with Section 01 74 00 - Cleaning.
- 3.6.3 Upon completion and verification of performance of installation, remove surplus materials, excess materials, rubbish, tools and equipment.

END OF SECTION

SECTION 233315:**DAMPERS-OPERATING****1. PART 1 GENERAL****1.1 SUMMARY****1.1.1 Section Includes:**

- 1.1.1.1 Operating dampers for mechanical forced air ventilation and air conditioning systems.

1.2 RELATED SECTIONS

- 1.2.1 Section 01 33 00 - Submittal Procedures.
- 1.2.2 Section 01 45 00 - Quality Control.
- 1.2.3 Section 01 74 21 - Construction/Demolition Waste Management and Disposal.
- 1.2.4 Section 01 78 00 - Closeout Submittals.

1.3 REFERENCES**1.3.1 American Society for Testing and Materials International (ASTM)**

- 1.3.1.1 ASTM A 653/A653M-04a, Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by Hot-Dip Process.

1.4 SUBMITTALS**1.4.1 Product Data:**

- 1.4.1.1 Submit manufacturer's printed product literature, specifications and datasheet in accordance with Section 01 33 00 - Submittal Procedures. Include product characteristics, performance criteria, and limitations.

- 1.4.1.2 Submit two copies of Workplace Hazardous Materials Information System (WHMIS) Safety Data Sheets (SDS) in accordance with Section 01 33 00 - Submittal Procedures.

1.4.1.3 Indicate the following:**1.4.1.3.1 Performance data.****1.4.1.3.2 Specifications**

- 1.4.2 Quality assurance submittals: submit following in accordance with Section 01 33 00 - Submittal Procedures.

- 1.4.2.1 Certificates: submit certificates signed by manufacturer certifying that materials comply with specified performance characteristics and physical properties.

- 1.4.2.2 Instructions: submit manufacturer's installation instructions.

1.4.3 Closeout Submittals:

- 1.4.3.1 Provide maintenance data for incorporation into manual specified in Section 01 78 00 - Closeout Submittals

1.5 QUALITY ASSURANCE

- 1.5.1 Health and Safety Requirements: Do construction occupational health and safety in accordance with Health and Safety Requirements.

1.5.2 Certificates:

- 1.5.2.1 Catalogue or published ratings those obtained from tests carried out by manufacturer or those ordered by manufacturer from independent testing agency.

1.6 DELIVERY, STORAGE, AND HANDLING**1.6.1 Packing, shipping, handling and unloading:**

1.6.1.1 Deliver, store and handle in accordance with manufacturer's written instructions and Section 01 61 00 - Common Product Requirements.

1.6.1.2 Deliver, store and handle materials in accordance with manufacturer's written instructions.

1.6.2 Waste Management and Disposal:

1.6.2.1 Construction/Demolition Waste Management and Disposal: separate waste materials for reuse and recycling in accordance with Section 01 74 21 - Construction/Demolition Waste Management and Disposal.

2. PART 2 PRODUCTS**2.1 MULTI-LEAF DAMPERS**

2.1.1 Opposed or parallel blade type as indicated.

2.1.2 Structurally formed steel or extruded aluminum, interlocking blades, complete with extruded vinyl seals, spring stainless steel side seals, structurally formed and welded galvanized steel or extruded aluminum frame.

2.1.3 Pressure fit self-lubricated bronze bearings.

2.1.4 Linkage: plated steel tie rods, brass pivots and plated steel brackets, complete with plated steel control rod.

2.1.5 Operator: to Section 25 30 02 - EMCS: Field Control Devices.

2.1.6 Performance:

2.1.6.1 Leakage: in closed position to be less than 2% of rated air flow at 500 Pa differential across damper.

2.1.6.2 Pressure drop: at full open position to be less than 25 Pa differential across damper at 10 m/s.

2.1.7 Insulated aluminum dampers:

2.1.7.1 Frames: insulated with extruded polystyrene foam with RSI factor of 5.0.

2.1.7.2 Blades: constructed from aluminum extrusions with internal hollows insulated with polyurethane or polystyrene foam, RSI factor of 5.0.

2.2 DISC TYPE DAMPERS

2.2.1 Frame: insulated brake formed, welded, 1.6 mm thick, galvanized steel to ASTM A 653M.

2.2.2 Disc: insulated spin formed, 1.6 mm thick, galvanized steel to ASTM A 653M.

2.2.3 Gasket: extruded neoprene, field replaceable, with 10 year warranty.

2.2.4 Bearings: roller self lubricated and sealed.

2.2.5 Operator: compatible with damper, linear stroke operator, spring loaded actuator, zinc-aluminum foundry alloy casting cam follower.

2.2.6 Performance:

2.2.6.1 Leakage: in closed position to be less than 2 % of rated air flow at 500 Pa pressure differential across damper.

2.2.6.2 Pressure drop: at full open position to be less than 25 Pa differential across damper at 10 m/s.

2.3 BACK DRAFT DAMPERS

2.3.1 Automatic gravity operated, multi leaf, aluminum or steel construction with nylon bearings, centre pivoted, spring assisted or counterweighted.

2.4 RELIEF DAMPERS

2.4.1 Automatic multi-leaf steel or aluminum dampers with ball bearing centre pivoted and counter-weights set to open as indicated.

3. PART 3 EXECUTION

3.1 INSTALLATION

- 3.1.1 Install where indicated.
- 3.1.2 Install in accordance with recommendations of SMACNA and manufacturer's instructions.
- 3.1.3 Seal multiple damper modules with silicon sealant.
- 3.1.4 Install access door adjacent to each damper. See Section 23 33 00 - Air Duct Accessories.
- 3.1.5 Ensure dampers are observable and accessible.

3.2 CLEANING

- 3.2.1 Proceed in accordance with Section 01 74 00 - Cleaning.
- 3.2.2 Upon completion and verification of performance of installation, remove surplus materials, excess materials, rubbish, tools and equipment.

END OF SECTION

SECTION 233316:**DAMPERS- FIRE AND SMOKE****1. PART 1 GENERAL****1.1 SUMMARY****1.1.1 Section Includes:**

1.1.1.1 Fire and smoke dampers, and fire stop flaps.

1.2 2.1 RELATED SECTIONS

1.2.1 Section 01 33 00 – Submittal Procedures.

1.2.2 Section 01 74 21 – Construction/Demolition Waste Management and Disposal.

1.2.3 Section 23 31 13.01 – Metal Ducts – Low Pressure to 500 Pa.

1.3 REFERENCES

1.3.1 American National Standards Institute/National Fire Protection Association (ANSI/NFPA)

1.3.1.1 ANSI/NFPA 90A, Standard for the Installation of Air Conditioning and Ventilating Systems.

1.3.2 Underwriters Laboratories of Canada (ULC)

1.3.2.1 CAN4-S112, Fire Test of Fire Damper Assemblies.

1.3.2.2 CAN4-S112.2, Standard Method of Fire Test of Ceiling Firestop Flap Assemblies.

1.3.2.3 ULC-S505, Fusible Links for Fire Protection Service.

1.4 SUBMITTALS**1.4.1 Product Data:**

1.4.1.1 Submit manufacturer's printed product literature, specifications and datasheet in accordance with Section 01 33 00 - Submittal Procedures. Include product characteristics, performance criteria, and limitations.

1.4.1.2 Submit two copies of Workplace Hazardous Materials Information System (WHMIS) Safety Data Sheets (SDS) in accordance with Section 01 33 00 - Submittal Procedures.

1.4.1.3 Indicate the following:

1.4.1.3.1 Fire dampers.

1.4.1.3.2 Smoke dampers.

1.4.1.3.3 Fire stop flaps.

1.4.1.3.4 Operators.

1.4.1.3.5 Fusible links.

1.4.1.3.6 Design details of break-away joints.

1.4.2 Quality assurance submittals: submit following in accordance with Section 01 33 00 - Submittal Procedures.

1.4.2.1 Certificates: submit certificates signed by manufacturer certifying that materials comply with specified performance characteristics and physical properties.

1.4.2.2 Instructions: submit manufacturer's installation instructions.

1.4.3 Closeout Submittals:

1.4.3.1 Provide maintenance data for incorporation into manual specified in Section 01 78 00 - Closeout Submittals

1.5 QUALITY ASSURANCE

1.5.1 Health and Safety Requirements: do construction occupational health and safety in accordance with - Health and Safety Requirements

1.5.2 Certificates:

- 1.5.2.1 Catalogue or published ratings those obtained from tests carried out by manufacturer or those ordered by manufacturer from independent testing agency signifying adherence to codes and standards.

1.6 MAINTENANCE

1.6.1 Extra Materials:

- 1.6.1.1 Provide maintenance materials in accordance with Section 01 78 00 - Closeout Submittals.

- 1.6.1.2 Provide the following:

- 1.6.1.2.1 6 fusible links of each type.

1.7 DELIVERY, STORAGE, AND HANDLING

1.7.1 Packing, shipping, handling and unloading:

- 1.7.1.1 Deliver, store and handle in accordance with Section 01 61 00 - Common Product Requirements.

- 1.7.1.2 Deliver, store and handle materials in accordance with manufacturer's written instructions.

1.7.2 Waste Management and Disposal:

- 1.7.2.1 Construction/Demolition Waste Management and Disposal: separate waste materials for reuse and recycling in accordance with Section 01 74 21 - Construction/Demolition Waste Management and Disposal.

2. PART2 PRODUCTS

2.1 FIRE DAMPERS

- 2.1.1 Fire dampers: arrangement Type B or C, blades out of air stream listed and bear label of ULC, meet requirements of provincial fire authority and ANSI/NFPA 90A. Fire damper assemblies to be fire tested in accordance with CAN4-S112. Minimum rating 1 ½ hours, dynamically rated.
- 2.1.2 Mild steel, factory fabricated for fire rating requirement to maintain integrity of fire wall and/or fire separation.
- 2.1.3 Top hinged: offset, round or square; multi-blade hinged or interlocking type; roll door type; or guillotine type; sized to maintain full duct cross section.
- 2.1.4 Fusible link actuated, weighted to close and lock in closed position when released or having negator-spring-closing operator for multi-leaf type or roll door type in horizontal position with vertical air flow.
- 2.1.5 Retaining angle iron frame, 40 x 40 x 3.0 mm, on full perimeter of fire damper, on both sides of fire separation being pierced.
- 2.1.6 Equip fire dampers with steel sleeve or frame installed to prevent disruption of ductwork or impair damper operation.
- 2.1.7 Equip sleeves or frames with perimeter mounting angles attached on both sides of wall or floor opening. Construct ductwork in fire-rated floor-ceiling or roof-ceiling assembly systems with air ducts that pierce ceiling to conform with ULC.
- 2.1.8 Design and construct dampers to not reduce duct or air transfer opening cross-sectional area.
- 2.1.9 Dampers shall be installed so that the centerline of the damper depth or thickness is located in the centerline of the wall, partition or floor slab depth or thickness.
- 2.1.10 Unless otherwise indicated, the installation details given in SMACNA Fire, Smoke, and Radiation Damper Installation Guide for HVAC and in manufacturer's instructions for fire dampers shall be followed.

2.2 SMOKE DAMPERS

- 2.2.1 To be ULC or UL listed and labelled.
- 2.2.2 Normally closed reverse action smoke vent (S/D-RASV): folding blade type, opening by gravity upon detection of smoke, and/or from remote alarm signalling device actuated by an electro thermal link. Two flexible stainless steel blade edge seals to provide required constant sealing pressure.
- 2.2.3 Normally open smoke/seal (S/D-SSSD): folding blade type, closing when actuated by means of electro thermal link and/or from remote alarm signalling device. Blade edge seals of flexible stainless steel shall provide required constant sealing pressure. Stainless steel negator springs with locking devices shall ensure positive closure for units mounted horizontally in vertical ducts.
- 2.2.4 Motorized (S/D-M): folding blade type, normally open with power on. When power is interrupted damper shall close automatically. Both damper and damper operator shall be ULC listed and labelled.
- 2.2.5 Electro thermal link (S/D-ETL): dual responsive fusible link which melts when subjected to local heat of 74° C and from external electrical impulse of low power and short duration; ULC or UL listed and labelled.

2.3 COMBINATION FIRE AND SMOKE DAMPERS

- 2.3.1 Damper: similar in all respects to smoke dampers specified above.
- 2.3.2 Combined actuator: electrical control system actuated from smoke sensor or smoke detection system and from fusible link.

2.4 FIRE STOP FLAPS

- 2.4.1 To be ULC listed and labelled and fire tested in accordance with CAN4-S112.2.
- 2.4.2 Construct of minimum 1.5 mm thick sheet steel with 1.6 mm thick non-asbestos ULC listed insulation and corrosion-resistant pins and hinges.
- 2.4.3 Flaps to be held open with fusible link conforming to ULC-S505 and close at 74° C.

3. PART3 EXECUTION**3.1 MANUFACTURER'S INSTRUCTIONS**

- 3.1.1 Compliance: comply with manufacturer's written recommendations or specifications, including product technical bulletins, handling, storage and installation instructions, and datasheet.

3.2 INSTALLATION

- 3.2.1 Install in accordance with ANSI/NFPA 90A and in accordance with conditions of ULC listing.
- 3.2.2 Maintain integrity of fire separation.
- 3.2.3 After completion and prior to concealment obtain approvals of complete installation from authority having jurisdiction.
- 3.2.4 Install access door adjacent to each damper. See Section 23 33 00 – Air Duct Accessories.
- 3.2.5 Coordinate with installer of firestopping to Section 07 84 00 – Firestopping.
- 3.2.6 Ensure access doors/panels, fusible links, damper operators are easily observed and accessible.
- 3.2.7 Install break-away joints of approved design on each side of fire separation.

3.3 CLEANING

- 3.3.1 Proceed in accordance with Section 01 74 00 - Cleaning.

- 3.3.2 Upon completion and verification of performance of installation, remove surplus materials, excess materials, rubbish, tools and equipment.
- 3.4 COMMISSIONING
 - 3.4.1 Commission in accordance with Section 01 91 13.13 – Commissioning (Cx) Requirements.

END OF SECTION**SECTION 233346:****FLEXIBLE DUCTS****1. PART1 GENERAL****1.1 SUMMARY**

- 1.1.1 Section Includes:
 - 1.1.1.1 Materials and installation of flexible ductwork, joints and accessories.

1.2 RELATED SECTIONS

- 1.2.1 Section 01 33 00 – Submittal Procedures.
- 1.2.2 Section 01 74 21 – Construction/Demolition Waste Management and Disposal.
- 1.2.3 Section 01 91 13.13 – Commissioning (Cx) Requirements.

1.3 REFERENCES

- 1.3.1 American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc. (ASHRAE).
- 1.3.2 Department of Justice Canada (Jus).
 - 1.3.2.1 Canadian Environmental Protection Act (CEPA).
 - 1.3.2.2 Transportation of Dangerous Goods Act, (TDGA).
- 1.3.3 National Fire Protection Association (NFPA).
 - 1.3.3.1 NFPA 90A, Standard for the Installation of Air-Conditioning and Ventilating Systems.
 - 1.3.3.2 NFPA 90B, Standard for Installation of Warm Air Heating and Air-Conditioning Systems.
- 1.3.4 Sheet Metal and Air-Conditioning Contractors' National Association (SMACNA).
 - 1.3.4.1 SMACNA HVAC Duct Construction Standards - Metal and Flexible.
 - 1.3.4.2 SMACNA IAQ Guideline for Occupied Buildings under Construction.
- 1.3.5 Underwriters' Laboratories Inc. (UL).
 - 1.3.5.1 UL 181, Standard for Factory-Made Air Ducts and Air Connectors.
- 1.3.6 Underwriters' Laboratories of Canada (ULC).
 - 1.3.6.1 CAN/ULC-S110, Standard Methods of Tests for Air Ducts.

1.4 SUBMITTALS

- 1.4.1 Make submittals in accordance with Section 01 33 00 - Submittal Procedures.
- 1.4.2 Submit WHMIS MSDS - Safety Data Sheets in accordance with Section 01 33 00 - Submittal Procedures.
 - 1.4.2.1 Thermal properties.
 - 1.4.2.2 Friction loss.
 - 1.4.2.3 Acoustical loss.

- 1.4.2.4 Leakage.
 - 1.4.2.5 Fire rating.
 - 1.4.3 Samples: submit samples with product data of different types of flexible duct being used in accordance with Section 01 33 00 - Submittal Procedures.
 - 1.5 QUALITY ASSURANCE
 - 1.5.1 Certification of Ratings:
 - 1.5.1.1 Catalogue or published ratings to be those obtained from tests carried out by manufacturer or independent testing agency signifying adherence to codes and standards.
 - 1.5.2 Health and Safety:
 - 1.5.2.1 Do construction occupational health and safety in accordance with Health and Safety Requirements.
 - 1.6 DELIVERY, STORAGE AND HANDLING
 - 1.6.1 Protect on site stored or installed absorptive material from moisture damage.
 - 1.6.2 Waste Management and Disposal:
 - 1.6.2.1 Separate waste materials for reuse and recycling in accordance with Section 01 74 21 - Construction/Demolition Waste Management and Disposal.
 - 1.6.2.2 Remove from site and dispose of packaging materials at appropriate recycling facilities.
 - 1.6.2.3 Collect and separate for disposal paper, plastic, polystyrene, corrugated cardboard packaging material in appropriate on-site bins for recycling in accordance with Waste Management Plan.
 - 1.6.2.4 Place materials defined as hazardous or toxic in designated containers.
 - 1.6.2.5 Handle and dispose of hazardous materials in accordance with CEPA, TDGA, Regional and Municipal regulations.
 - 1.6.2.6 Ensure emptied containers are sealed and stored safely.
 - 1.6.2.7 Fold up metal and plastic banding, flatten and place in designated area for recycling.
 - 1.7 INDOOR AIR QUALITY (IAQ)
 - 1.7.1 During construction, meet or exceed the requirements of SMACNA IAQ Guideline for Occupied Buildings under Construction.
2. PART 2 PRODUCTS
- 2.1 GENERAL
 - 2.1.1 Factory fabricated to CAN/ULC S110.
 - 2.1.2 Pressure drop coefficients listed below are based on relative sheet metal duct pressure drop coefficient of 1.00.
 - 2.1.3 Flame spread rating not to exceed 25. Smoke developed rating not to exceed 50.
 - 2.2 METALLIC - UNINSULATED
 - 2.2.1 Type 1: spiral wound flexible aluminum.
 - 2.2.2 Performance:
 - 2.2.2.1 Factory tested to 1000 Pa without leakage.
 - 2.2.2.2 Maximum relative pressure drop coefficient: 3.
 - 2.3 METALLIC - INSULATED
 - 2.3.1 Type 2: spiral wound flexible aluminum with factory applied, 25 mm thick flexible glass fibre thermal insulation with vapour barrier and vinyl or reinforced mylar/neoprene laminate jacket.
 - 2.3.2 Performance:

- 2.3.2.1 Factory tested to 1000 Pa without leakage.
- 2.3.2.2 Maximum relative pressure drop coefficient: 3.
- 2.3.2.3 Thermal loss/gain: 1.3 W/m².°C mean.

2.4 NON-METALLIC - UNINSULATED

- 2.4.1 Type 3: non-collapsible, coated mineral base fabric or aluminum foil mylar type, mechanically bonded to, and helically supported by, external steel wire.
- 2.4.2 Performance:
 - 2.4.2.1 Factory tested to 1000 Pa without leakage.
 - 2.4.2.2 Maximum relative pressure drop coefficient: 3.

2.5 NON-METALLIC - INSULATED

- 2.5.1 Type 4: non-collapsible, coated mineral base fabric or aluminum foil mylar type mechanically bonded to, and helically supported by, external steel wire with factory applied, 25 mm thick flexible glass fibre thermal insulation with vapour barrier and vinyl or reinforced mylar/neoprene laminate jacket.
- 2.5.2 Performance:
 - 2.5.2.1 Factory tested to 1000 Pa without leakage.
 - 2.5.2.2 Maximum relative pressure drop coefficient: 3.
 - 2.5.2.3 Thermal loss/gain: 1.3 W/m² °C mean.

2.6 METALLIC ACOUSTIC INSULATED MEDIUM PRESSURE

- 2.6.1 Type 5: Spiral wound, flexible perforated aluminum with factory applied 25 mm thick flexible glass fibre thermal insulation and sleeved by aluminum foil and mylar laminate vapour barrier.
- 2.6.2 Performance:
 - 2.6.2.1 Factory tested to 3 kPa without leakage.
 - 2.6.2.2 Maximum relative pressure drop coefficient: 3.
 - 2.6.2.3 Acoustical performance: Minimum attenuation (dB/m) to following table:

Duct Diam:	Frequency (Hz)				
	125	250	500	1000	2000
100	0.6	3	12	27	0
150	1.2	3	12	22	27
200	2.0	5	12	19	20
300	2.4	5	12	16	15

2.7 METALLIC ACOUSTIC INSULATED HIGH PRESSURE

- 2.7.1 Type 6: Spiral wound, flexible perforated aluminum with factory applied 37 mm thick flexible glass fibre thermal insulation and encased in spiral wound flexible aluminum jacket, as indicated.
- 2.7.2 Performance:
 - 2.7.2.1 Factory tested to 2.5 kPa without leakage.
 - 2.7.2.2 Maximum relative pressure drop coefficient: 3.
 - 2.7.2.3 Acoustical performance: Minimum attenuation (dB/m) to following table:

Duct Diam:	Frequency (Hz)				
	125	250	500	1000	2000
100	0.6	3	12	27	0
150	1.2	3	12	22	27
200	2.0	5	12	19	20
300	2.4	5	12	16	15

2.8 NON-METALLIC - ACOUSTIC INSULATED

2.8.1 Type 7: Non-collapsible, coated mineral base perforated fabric type helically supported by and mechanically bonded to steel wire with factory applied flexible glass fibre acoustic insulation and encased in aluminum foil and mylar laminate vapour barrier.

2.8.2 Performance:

2.8.2.1 Factory tested to 3 kPa without leakage.

2.8.2.2 Maximum relative pressure drop coefficient: 3.

2.8.2.3 Acoustical performance: Minimum attenuation (dB/m) to following table:

	Frequency (Hz)				
Duct Diam:	125	250	500	1000	2000
100	0.6	3	12	27	0
150	1.2	3	12	22	27
200	2.0	5	12	19	20
300	2.4	5	12	16	15

3. PART 3 EXECUTION**3.1 DUCT INSTALLATION**

3.1.1 Install in accordance with: NFPA 90A and NFPA 90B SMACNA.

3.1.2 Do leakage test in accordance with Section 23 05 94 - Pressure Testing of Ducted Air System.

3.1.3 Do trial test to demonstrate workmanship.

END OF SECTION

SECTION 233353:**DUCT LINERS****1. PART 1 GENERAL****1.1 SECTION INCLUDES**

1.1.1 Materials and installation for acoustic duct lining.

1.2 RELATED SECTIONS

1.2.1 Section 01 33 00 - Submittal Procedures.

1.2.2 Section 01 74 21 - Construction/Demolition Waste Management and Disposal.

1.3 REFERENCES

1.3.1 American Society for Testing and Materials International, (ASTM).

1.3.1.1 ASTM C 423, Standard Test Method for Sound Absorption and Sound Absorption Coefficients by the Reverberation Room Method.

1.3.1.2 ASTM C 916, Standard Specification for Adhesives for Duct Thermal Insulation.

1.3.1.3 ASTM C 1071, Standard specification for Fibrous Glass Duct Lining Insulation (Thermal and Sound Absorbing Material).

- 1.3.1.4 ASTM C 1338, Standard Test Method for Determining Fungi Resistance of Insulation Materials and Facings.
- 1.3.1.5 ASTM G 21, Standard Practice for Determining Resistance of Synthetic Polymeric Materials to Fungi.
- 1.3.2 Department of Justice Canada (Jus).
 - 1.3.2.1 Canadian Environmental Protection Act (CEPA).
- 1.3.3 National Fire Protection Association (NFPA).
 - 1.3.3.1 NFPA 90A, Standard for the Installation of Air Conditioning and Ventilating Systems.
 - 1.3.3.2 NFPA 90B, Standard for the Installation of Warm Air Heating and Air Conditioning Systems.
- 1.3.4 Thermal Insulation Association of Canada (TIAC).
 - 1.3.4.1 National Insulation Standards.
- 1.3.5 Sheet Metal and Air Conditioning Contractor's National Association (SMACNA).
 - 1.3.5.1 SMACNA, HVAC, Duct Construction Standards, Metal and Flexible.
 - 1.3.5.2 SMACNA IAQ Guideline for Occupied Buildings Under Construction.
- 1.3.6 Transport Canada (TC).
 - 1.3.6.1 Transportation of Dangerous Goods Act (TDGA), 1992, c. 34.
- 1.3.7 Underwriter's Laboratories of Canada (ULC).
 - 1.3.7.1 CAN/ULC-S102, Methods of Test for Surface Burning Characteristics of Building Materials and Assemblies.
- 1.4 SUBMITTALS
 - 1.4.1 Submit product data in accordance with Section 01 33 00 - Submittal Procedures.
 - 1.4.2 Submit WHMIS MSDS - Safety Data Sheets in accordance with Section 01 33 00 - Submittal Procedures.
- 1.5 HEALTH AND SAFETY
 - 1.5.1 Do construction occupational health and safety in accordance with - Health and Safety Requirements.
- 1.6 DELIVERY, STORAGE AND HANDLING
 - 1.6.1 Store and manage hazardous materials in accordance with Section 02 62 00.01 - Hazardous Materials.
 - 1.6.2 Protect on site stored or installed absorptive material from moisture damage.
- 1.7 WASTE MANAGEMENT AND DISPOSAL
 - 1.7.1 Separate waste materials for reuse and recycling in accordance with Section 01 74 21 - Construction/Demolition Waste Management and Disposal.
 - 1.7.2 Remove from site and dispose of packaging materials at appropriate recycling facilities.
 - 1.7.3 Collect and separate for disposal, paper, plastic, polystyrene, corrugated cardboard packaging material in appropriate on-site bins for recycling in accordance with Waste Management Plan.
 - 1.7.4 Place materials defined as hazardous or toxic in designated containers.
 - 1.7.5 Handle and dispose of hazardous materials in accordance with CEPA, TDGA, Regional and Municipal regulations.
 - 1.7.6 Ensure emptied containers are sealed and stored safely.
 - 1.7.7 Fold up metal banding, flatten and place in designated area for recycling.

2. PART 2 PRODUCTS**2.1 DUCT LINER****2.1.1 General:**

2.1.1.1 Mineral Fibre duct liner: air surface coated mat facing.

2.1.1.2 Flame spread rating shall not exceed 25. Smoke development rating shall not exceed 50 when tested in accordance with CAN/ULC-S102, NFPA 90A and NFPA 90B.

2.1.1.3 Fungi resistance: to ASTM C 1338, ASTM G 21.

2.1.2 Rigid:

2.1.2.1 Use on flat surfaces where indicated

2.1.2.2 25 mm thick, to ASTM C 1071, Type 2, fibrous glass rigid board duct liner.

2.1.2.3 Density: 48 kg/m³ minimum.

2.1.2.4 Thermal resistance to be minimum 0.76 (m².degrees C)/W for 25 mm thickness, 1.15 (m².degrees C)/W for 38 mm thickness, 1.53 (m².degrees C)/W for 50 mm thickness when tested in accordance with ASTM C 177, at 24 degrees C mean temperature.

2.1.2.5 Maximum velocity on faced air side: 20.3 m/sec.

2.1.2.6 Minimum NRC of 0.70 at 25 mm thickness based on Type A mounting to ASTM C 423.

2.1.3 Flexible:

2.1.3.1 Use on round or oval surfaces.

2.1.3.2 25 mm thick, to ASTM C 1071 Type 1, fibrous glass blanket duct liner.

2.1.3.3 Density: 24 kg/m³ minimum.

2.1.3.4 Thermal resistance to be minimum 0.37 (m².degrees C)/W for 12 mm thickness, 0.74 (m².degrees C)/W for 25 mm thickness, 1.11 (m².degrees C)/W for 38 mm thickness, 1.41 (m².degrees C)/W for 50 mm thickness when tested in accordance with ASTM C 177, at 24 degrees C mean temperature.

2.1.3.5 Maximum velocity on coated air side: 25.4 m/sec.

2.1.3.6 Minimum NRC of 0.65 at 25 mm thickness based on Type A mounting to ASTM C 423.

2.2 ADHESIVE

2.2.1 Adhesive: to NFPA 90A and NFPA 90B, ASTM C916.

2.2.2 Flame spread rating shall not exceed 25. Smoke development rating shall not exceed 50. Temperature range minus 29 degrees C to plus 93 degrees C.

2.2.3 Water-based fire-retardant type.

2.3 FASTENERS

2.3.1 Weld pins 2.0 mm diameter, length to suit thickness of insulation. Metal retaining clips, 32 mm square.

2.4 JOINT TAPE

2.4.1 Poly-Vinyl treated open weave fiberglass membrane 50 mm wide.

2.5 SEALER

2.5.1 Meet requirements of NFPA 90A and NFPA 90B.

2.5.2 Flame spread rating shall not exceed 25. Smoke development rating shall not exceed 50. Temperature range minus 68 degrees C to plus 93 degrees C.

3. PART3 EXECUTION

3.1 GENERAL

- 3.1.1 Do work in accordance with SMACNA HVAC DCS, TIAC, and as indicated except as specified otherwise.
- 3.1.2 Line inside of ducts where indicated.
- 3.1.3 Duct dimensions, as indicated, are clear inside duct lining.

3.2 DUCT LINER

- 3.2.1 Install in accordance with manufacturer's recommendations, and as follows:
 - 3.2.1.1 Fasten to interior sheet metal surface with 100 % coverage of adhesive to ASTM C 916
 - 3.2.1.1.1 Exposed leading edges and transverse joints to be factory coated or coated with adhesive during fabrication.
 - 3.2.1.2 In addition to adhesive, install weld pins not less than 2 rows per surface and not more than 425 mm on centres impact driven mechanical fasteners to compress duct liner sufficiently to hold it firmly in place.
 - 3.2.1.2.1 Spacing of mechanical fasteners in accordance with SMACNA HVAC DCS, TIAC.
 - 3.2.2 In systems, where air velocities exceed 20.3 m/sec, install galvanized sheet metal nosing to leading edges of duct liner.
- 3.3 JOINTS**
- 3.3.1 Seal butt joints, exposed edges, weld pin and clip penetrations and damaged areas of liner with joint tape and sealer. Install joint tape in accordance with manufacturer's written recommendations, and as follows:
 - 3.3.1.1 Bed tape in sealer.
 - 3.3.1.2 Apply two coats of sealer over tape.
 - 3.3.2 Replace damaged areas of liner at discretion of Owner.
 - 3.3.3 Protect leading and trailing edges of duct sections with sheet metal nosing having 15 mm overlap and fastened to duct.

END OF SECTION

SECTION 233400:**DOMESTIC FANS****1. PART1 GENERAL****1.1 SUMMARY****1.1.1 Section Includes:**

- 1.1.1.1 Fans, window ventilators, exterior, wall and ceiling mounted discharge fans for domestic use.

1.2 RELATED SECTIONS

- 1.2.1 Section 01 33 00 – Submittal Procedures
- 1.2.2 Section 01 74 21 – Construction/Demolition Waste Management and Disposal.
- 1.2.3 Section 01 78 00 – Closeout Submittals
- 1.2.4 Section 23 05 13 – Common Motor Requirements for HVAC Equipment.
- 1.2.5 Section 23 05 48 – Vibration and Seismic Controls for HVAC Piping and Equipment.
- 1.2.6 Section 23 33 00 – Air Duct Accessories.

1.3 REFERENCES

- 1.3.1 American National Standards Institute/Air Movement and Control Association (ANSI/AMCA)
 - 1.3.1.1 ANSI/AMCA 201, Fans and Systems.
 - 1.3.1.2 ANSI/AMCA Standard 300, Reverberant Room Method for Sound Testing of Fans.
 - 1.3.1.3 ANSI/AMCA Standard 301, Methods for Calculating Fan Sound Ratings from Laboratory Test Data.
 - 1.3.1.4 ANSI/ AMCA 302, Application of Sone Ratings for Non-Ducted Air Moving Devices.
 - 1.3.1.5 ANSI/ AMCA 303, Application of Sound Power Level Ratings for Fans.
- 1.3.2 American National Standards Institute (ANSI)/American Society of Mechanical Engineers (ASME)
 - 1.3.2.1 ANSI/AMCA 210, Laboratory Methods of Testing Fans for Aerodynamic Performance Rating.

1.4 SYSTEM DESCRIPTION**1.4.1 Performance Requirements:**

- 1.4.1.1 Catalogued or published ratings for manufactured items: obtained from tests carried out by manufacturer or those ordered by manufacturer from independent testing agency signifying adherence to codes and standards in force.

1.5 SUBMITTALS**1.5.1 Product Data:**

- 1.5.1.1 Submit manufacturer's printed product literature, specifications and datasheet in accordance with Section 01 33 00 - Submittal Procedures. Include product characteristics, performance criteria, and limitations.
 - 1.5.1.1.1 Submit two copies of Workplace Hazardous Materials Information System (WHMIS) Safety Data Sheets (SDS) in accordance with Section 01 33 00 - Submittal Procedures.

1.5.2 Shop Drawings:

- 1.5.2.1 Submit shop drawings in accordance with Section 01 33 00 - Submittal Procedures

- 1.5.2.2 Indicate following: dimensions, performance, sound rating, and installation procedure.
- 1.5.3 Quality assurance submittals: submit following in accordance with Section 01 33 00 - Submittal Procedures.
 - 1.5.3.1 Certificates: submit certificates signed by manufacturer certifying that materials comply with specified performance characteristics and physical properties.
 - 1.5.3.2 Instructions: submit manufacturer's installation instructions.
- 1.5.4 Closeout Submittals
 - 1.5.4.1 Provide maintenance data for incorporation into manual specified in Section 01 78 00 - Closeout Submittals
- 1.6 QUALITY ASSURANCE
 - 1.6.1 Health and Safety Requirements: do construction occupational health and safety in accordance with - Health and Safety Requirements.
- 1.7 MAINTENANCE
 - 1.7.1 Extra Materials:
 - 1.7.1.1 Provide maintenance materials in accordance with Section 01 78 00 - Closeout Submittals.
 - 1.7.1.2 Furnish list of individual manufacturer's recommended spare parts for equipment, include:
 - 1.7.1.2.1 Bearings and seals.
 - 1.7.1.2.2 Belts
 - 1.7.1.2.3 Addresses of suppliers.
 - 1.7.1.2.4 List of specialized tools necessary for adjusting, repairing or replacing.
- 1.8 DELIVERY, STORAGE, AND HANDLING
 - 1.8.1 Packing, shipping, handling and unloading:
 - 1.8.1.1 Deliver, store and handle in accordance with Section 01 61 00 - Common Product Requirements.
 - 1.8.1.2 Deliver, store and handle materials in accordance with manufacturer's written instructions.
 - 1.8.2 Waste Management and Disposal:
 - 1.8.2.1 Construction/Demolition Waste Management and Disposal: separate waste materials for reuse and recycling in accordance with Section 01 74 21 - Construction/Demolition Waste Management and Disposal.
- 2. PART2 PRODUCTS
 - 2.1 FANS GENERAL
 - 2.1.1 Standard of rating:
 - 2.1.1.1 AMCA 201 for fan application.
 - 2.1.1.2 AMCA 302 for application of some loudness ratings for non-ducted air moving devices.
 - 2.1.1.3 AMCA 303 for application of sound power ratings for ducted air moving devices.
 - 2.1.1.4 Performance: to ANSI/AMCA 210 and ANSI/ASHRAE 51.
 - 2.1.2 Pwl sound ratings to comply with AMCA 301, tested to AMCA 300
 - 2.1.3 Maximum loudness: 5 sones.
 - 2.2 EXTERIOR MOUNTED DISCHARGE FANS
 - 2.2.1 Wall or Roof mounted, direct driven centrifugal fan, ball bearing thermally protected motor.
 - 2.2.2 Sizes and capacity: see schedule
 - 2.2.3 Control: switch or thermostatically operated.

- 2.2.4 Rust resistant aluminum or zinc coated steel, baked-on enamel finish with aluminum backdraft damper, spring loaded complete with foam cushioned frame.
- 2.3 WALL AND CEILING DISCHARGE FANS
 - 2.3.1 Centrifugal direct drive, with plug-in type electric motor suitable for ceiling or wall installation, zinc coated rectangular metal housing.
 - 2.3.2 Sizes and capacity: see schedule.
 - 2.3.3 Toggle switch or timer operated complete with integral electrical outlet box with plug-in type receptacle.
 - 2.3.4 Top or side 80 mm x 250 mm rectangular duct outlet with integral backdraft damper.
 - 2.3.5 Roof jack or wall cap complete with spring loaded backdraft damper with neoprene gasket.
 - 2.3.6 White polymeric or silver anodized aluminum grille.
- 3. PART 3 EXECUTION
 - 3.1 MANUFACTURER'S INSTRUCTIONS
 - 3.1.1 Compliance: comply with manufacturer's written recommendations or specifications, including product technical bulletins, handling, storage and installation instructions, and datasheet.
 - 3.2 INSTALLATION
 - 3.2.1 Install in accordance with manufacturer's recommendations.
 - 3.3 ANCHOR BOLTS AND TEMPLATES
 - 3.3.1 Supply for installation by other divisions.
 - 3.4 CLEANING
 - 3.4.1 Proceed in accordance with Section 01 74 00 - Cleaning.
 - 3.4.2 Upon completion and verification of performance of installation, remove surplus materials, excess materials, rubbish, tools and equipment.
 - 3.5 COMMISSIONING
 - 3.5.1 Commission in accordance with Section 01 91 13.13 - Commissioning (Cx) Requirements.

END OF SECTION

SECTION 233400:**HVAC FANS****1. PART 1 GENERAL****1.1 SUMMARY****1.1.1 Section Includes:**

1.1.1.1 Fans, motors, accessories, and hardware for commercial use.

1.2 RELATED SECTIONS

1.2.1 Section 01 33 00 – Submittal Procedures

1.2.2 Section 01 74 21 – Construction/Demolition Waste Management and Disposal.

1.2.3 Section 01 78 00 – Closeout Submittals

1.2.4 Section 23 05 13 – Common Motor Requirements for HVAC Equipment.

1.2.5 Section 23 05 48 – Vibration and Seismic Control for HVAC Piping and Equipment.

1.2.6 Section 23 33 00 – Air Duct Accessories.

1.3 REFERENCES

1.3.1 American National Standards Institute/Air Movement and Control Association (ANSI/AMCA)

1.3.1.1 ANSI/AMCA Standard 99, Standards Handbook.

1.3.1.2 ANSI/AMCA Standard 300, Reverberant Room Method for Sound Testing of Fans.

1.3.1.3 ANSI/AMCA Standard 301, Methods for Calculating Fan Sound Ratings from Laboratory Test Data.

1.3.2 American National Standards Institute (ANSI)/American Society of Mechanical Engineers (ASME)

1.3.2.1 ANSI/AMCA 210, Laboratory Methods of Testing Fans for Aerodynamic Performance Rating.

1.3.3 American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE)

1.3.3.1 ASHRAE 51, Laboratory Methods of Testing Fans for Aerodynamic Performance Rating.

1.3.4 National Electrical Manufacturers Association (NEMA)

1.3.4.1 NEMA MG 1 Motors and Generators

1.3.4.2 NEMA ICS 7.1 Safety Standard for Construction and Guide for Selection, Installation and Operation of Adjustable Drive Systems.

1.3.5 The Master Painters Institute (MPI)

1.3.5.1 Architectural Painting Specification Manual, MPI #18, Primer, Zinc Rich, Organic.

1.4 SYSTEM DESCRIPTION**1.4.1 Performance Requirements:**

1.4.1.1 Catalogued or published ratings for manufactured items: obtained from tests carried out by manufacturer or those ordered by manufacturer from independent testing agency signifying adherence to codes and standards in force.

1.4.1.2 Capacity: flow rate, total static pressure, bhp W, efficiency, revolutions per minute, power, model, size, sound power data and as indicated on schedule.

1.4.1.3 Fans: statically and dynamically balanced, constructed in conformity with AMCA 99.

1.4.1.4 Sound ratings: comply with AMCA 301, tested to AMCA 300. Supply unit with AMCA certified sound rating seal.

- 1.4.1.5 Performance ratings: based on tests performed in accordance with ANSI/AMCA 210. Supply unit with AMCA certified rating seal, except for propeller fans smaller than 300 mm diameter.

1.5 SUBMITTALS

1.5.1 Product Data:

- 1.5.1.1 Submit manufacturer's printed product literature, specifications and datasheet in accordance with Section 01 33 00 - Submittal Procedures. Include product characteristics, performance criteria, and limitations.

- 1.5.1.1.1 Submit two copies of Workplace Hazardous Materials Information System (WHMIS) Safety Data Sheets (SDS) in accordance with Section 01 33 00 - Submittal Procedures.

1.5.2 Shop Drawings:

- 1.5.2.1 Submit shop drawings and product data in accordance with Section 01 33 00 - Submittal Procedures.

1.5.3 Provide:

- 1.5.3.1 Fan performance curves showing point of operation, BHP kW and efficiency.
- 1.5.3.2 Sound rating data at point of operation.
- 1.5.3.3 Dimensional data.
- 1.5.3.4 Installation procedures.

1.5.4 Indicate:

- 1.5.4.1 Motors, sheaves, bearings, shaft details
- 1.5.4.2 Minimum performance achievable with variable speed controllers and variable inlet vanes as appropriate.

1.5.5 Quality assurance submittals: submit following in accordance with Section 01 33 00 - Submittal Procedures.

- 1.5.5.1 Certificates: submit certificates signed by manufacturer certifying that materials comply with specified performance characteristics and physical properties.
- 1.5.5.2 Instructions: submit manufacturer's installation instructions.

1.5.6 Closeout Submittals:

- 1.5.6.1 Provide operation and maintenance data for incorporation into manual specified in Section 01 78 00 - Closeout Submittals.

1.6 QUALITY ASSURANCE

- 1.6.1 Health and Safety Requirements: do construction occupational health and safety in accordance with - Health and Safety Requirements.

1.7 MAINTENANCE

1.7.1 Extra Materials:

- 1.7.1.1 Provide maintenance materials in accordance with Section 01 78 00 - Closeout Submittals.

- 1.7.1.1.1 Spare parts to include:

- 1.7.1.1.1.1 Matched sets of belts.

- 1.7.1.2 Furnish list of individual manufacturer's recommended spare parts for equipment, include:

- 1.7.1.2.1 Bearings and seals.

- 1.7.1.2.2 Belts

- 1.7.1.2.3 Addresses of suppliers.

- 1.7.1.2.4 List of specialized tools necessary for adjusting, repairing or replacing.

1.8 DELIVERY, STORAGE, AND HANDLING

- 1.8.1 Packing, shipping, handling and unloading:

- 1.8.1.1 Deliver, store and handle in accordance with Section 01 61 00 - Common Product Requirements.
 - 1.8.1.2 Deliver, store and handle materials in accordance with manufacturer's written instructions.
 - 1.8.2 Waste Management and Disposal:
 - 1.8.2.1 Construction/Demolition Waste Management and Disposal: separate waste materials for reuse and recycling in accordance with Section 01 74 21 - Construction/Demolition Waste Management and Disposal.
2. PART2 PRODUCTS
- 2.1 FANS GENERAL
- 2.1.1 Capacity: flow rate, static pressure, bhp, efficiency, revolutions per minute, power, model, size, sound power data and as indicated on schedule.
 - 2.1.2 Fans: statically and dynamically balanced, constructed in conformity with AMCA 99.
 - 2.1.3 Sound ratings: comply with AMCA 301, tested to AMCA 300. Unit shall bear AMCA certified sound rating seal.
 - 2.1.4 Performance ratings: based on tests performed in accordance with ANSI/AMCA 210, and ANSI/ASHRAE 51. Unit shall bear AMCA certified rating seal, except for propeller fans smaller than 300 mm diameter.
 - 2.1.5 Motors:
 - 2.1.5.1 Open drip proof outside of air stream, TEFC when in air stream, explosion proof as indicated in accordance with NEMA MG1.
 - 2.1.5.2 In accordance with Section 23 05 13 - Common Motor Requirements for HVAC Equipment supplemented as specified herein.
 - 2.1.5.3 For use with variable speed controllers where specified.
 - 2.1.5.4 Sizes as specified.
 - 2.1.5.5 Two speed with two windings and speeds of approximately 1200 or 900 r/min low and 1800 r/min high as indicated.
 - 2.1.5.6 Two speeds with split winding, constant horsepower or constant or variable torque as specified and speeds as indicated.
 - 2.1.6 Accessories and hardware: matched sets of V-belt drives, adjustable slide rail motor bases, belt guards, coupling guards, fan inlet and/or outlet safety screens as indicated and as specified in Section 23 05 13 - Common Motor Requirements for HVAC Equipment, inlet or outlet dampers and vanes and as indicated.
 - 2.1.7 Factory primed before assembly in colour standard to manufacturer.
 - 2.1.8 Scroll casing drains: as indicated.
 - 2.1.9 Finish on fume hood exhaust fans: heresite coated
 - 2.1.10 Bearing lubrication systems plus extension lubrication tubes where bearings are not easily accessible.
 - 2.1.11 Vibration isolation: to Section 23 05 48 - Vibration and Seismic Control for HVAC Piping and Equipment.
 - 2.1.12 Flexible connections: to Section 23 33 00 - Air Duct Accessories.
- 2.2 CENTRIFUGAL FANS
- 2.2.1 Fan wheels:
 - 2.2.1.1 Welded steel or aluminum construction.
 - 2.2.1.2 Maximum operating speed of centrifugal fans not more than 40 % of first critical speed.
 - 2.2.1.3 Air foil or backward inclined blades, as indicated.

- 2.2.2 Bearings: air handling quality, heavy duty, split pillow-block, flange mounted grease lubricated ball or roller self aligning type with oil retaining, dust excluding seals and a certified minimum rated life to ABMA L10 of 100,000 hours. Shaft seals on laboratory fume hood and biological safety cabinet exhaust fans:
 - 2.2.2.1 Single disc or stuffing box seals.
- 2.2.3 Housings:
 - 2.2.3.1 Volute with inlet cones: fabricated steel for wheels 300 mm or greater, cast iron, or steel, for smaller wheels, braced, and with welded supports.
 - 2.2.3.2 For horizontally and vertically split housings provide flanges on each section for bolting together, with gaskets of non-oxidizing non-flammable material.
 - 2.2.3.3 Provide bolted latched airtight access doors with handles.
 - 2.2.3.4 Spark resistant construction Type B minimum where indicated.
- 2.2.4 Variable volume control devices:
 - 2.2.4.1 Mounted by fan manufacturer.
 - 2.2.4.2 Adjustable inlet vanes: operated from a centre mechanism linked to each damper vane. Support each vane at ends in bronze bearings. On DWDI fans interconnect vanes to operate in unison. Provide locking devices for manual operation.
 - 2.2.4.3 Variable Speed Drives: to NEMA ICS 7.1.
- 2.3 CABINET FANS - GENERAL PURPOSE
 - 2.3.1 Fan characteristics and construction: as centrifugal fans.
 - 2.3.2 Cabinet hung single or multiple wheels with DWDI centrifugal fans in factory fabricated casing complete with vibration isolators and seismic control measures, motor, direct drive or V-belt drive and guard outside casing.
 - 2.3.3 Fabricate casing of zinc coated or phosphate treated steel reinforced and braced for rigidity. Provide removable panels for access to interior. Uncoated, steel parts shall be painted over with corrosion resistant paint to MPI #18. Finish inside and out, over prime coat, with rust resistant enamel to Section 09 91 13 - Exterior Painting. Internally line cabinet with 12-25 mm thick rigid acoustic insulation, pinned and cemented, complete with metal nosings on all exposed edges.
- 2.4 UTILITY SETS
 - 2.4.1 Characteristics and construction: for centrifugal fans.
 - 2.4.2 Preassemble single width centrifugal fan with removable protective hood with vents, and automatic spring loaded back draft dampers and 12 mm mesh birdscreens where indicated.
 - 2.4.3 Provide belt driven sets with adjustable motor bed plate and variable pitch driver sheave.
- 2.5 AXIAL FLOW FANS (TUBE-AXIAL OR VANE-AXIAL)
 - 2.5.1 Casings: welded steel with welded motor support, hinged or bolted access plates, streamlined inlet cone and discharge bell sections.
 - 2.5.2 Blade material: steel or aluminum. Hub material: steel or aluminum.
 - 2.5.3 Supports:
 - 2.5.3.1 Floor mounted units: reinforced legs.
 - 2.5.3.2 Ceiling suspended units: support brackets welded to side of casing. Extend grease lubrication facilities to outside of casing.
 - 2.5.4 Bearings: ball or roller with extension tubes to outside of casing.
 - 2.5.5 Direct drive:

- 2.5.5.1 Adjustable or fixed blade wheels as indicated: totally-enclosed, air over motors.
- 2.5.5.2 Diameter of wheel hub: at least equal to that of motor frame.
- 2.5.5.3 Adjustable blades for varying range of volume and pressure. Provide permanent pitch angle indication vernier scale on hub. Provide for automatic adjustment while in motion. Provide adjustment stops to avoid overloading motor.
- 2.5.5.4 Variable speed drives: to NEMA ICS 7.1.
- 2.5.6 Belt drive:
 - 2.5.6.1 Fixed or adjustable blade as indicated by externally mounted motors through V-belt drive. Provide internal belt fairing, external belt guards and adjustable motor mounts.
 - 2.5.6.2 Adjust blades for varying range of volume and pressure. Hubs shall facilitate indexing of blade angle. Provide automatic adjustment stops to avoid overloading motor.
 - 2.5.6.3 Variable speed drives: to NEMA ICS 7.1.
- 2.6 IN-LINE CENTRIFUGAL FANS
 - 2.6.1 Characteristics and construction: as for centrifugal fan wheels, with axial flow construction and direct or belt drive as indicated.
 - 2.6.2 Provide AMCA arrangements 1 or 9 as indicated with stiffened flanges, smooth rounded inlets, and stationary guide vanes.
- 2.7 PROPELLER FANS
 - 2.7.1 Fabricate multibladed propellers of sheet steel or aluminum of airfoil shape within bell mouth entrance on integral mounts, with grease lubricated ball bearings, with extended lubrication fittings, suited for operating in any position, direct or belt driven, complete with motor as indicated.
 - 2.7.2 Provide blade guards, bird screen and automatic back draft dampers on discharge, with gasketed edges.
- 3. PART3 EXECUTION
 - 3.1 MANUFACTURER'S INSTRUCTIONS
 - 3.1.1 Compliance: comply with manufacturer's written recommendations or specifications, including product technical bulletins, handling, storage and installation instructions, and datasheet.
 - 3.2 FAN INSTALLATION
 - 3.2.1 Install fans as indicated, complete with resilient mountings specified in Section 23 05 48 - Vibration and Seismic Control for HVAC and Piping Equipment, flexible electrical leads and flexible connections in accordance with Section 23 33 00 - Air Duct Accessories.
 - 3.2.2 Provide sheaves and belts required for final air balance.
 - 3.2.3 Bearings and extension tubes to be easily accessible.
 - 3.2.4 Access doors and access panels to be easily accessible.
 - 3.3 CLEANING
 - 3.3.1 Proceed in accordance with Section 01 74 00 - Cleaning.
 - 3.3.2 Upon completion and verification of performance of installation, remove surplus materials, excess materials, rubbish, tools and equipment.
 - 3.4 COMMISSIONING
 - 3.4.1 Commissioning in accordance with Section 01 91 13.13 - Commissioning (Cx) Requirements.

END OF SECTION

PACKAGEED ROOF AND WALL

1.1 SUMMARY

1.1.1.1 Roof and wall exhausters.

1.2.1 Section 01 33 00 – Submittal Procedures.

1.2.3 Section 01 78 00 – Closeout Submittals.

1.3 REFERENCES

1.3.2 Air Movement and Control Association (AMCA)

1.3.2.2 AMCA 300, Reverberant Room Method for Sound Testing of Fans.

1.3.3 American National Standards Institute (ANSI)

1.4 SYSTEM DESCRIPTION

1.4.1.1 Catalogued or published ratings for manufactured items:
obtained from tests carried out by manufacturer or those

ordered by manufacturer from independent testing agency signifying adherence to codes and standards in force. Provide confirmation of testing.

1.4.1.2 Capacity: flow rate, total static pressure Pa, r/min, bhp W, model and size and sound ratings as indicated on schedule.

1.4.2 Statically and dynamically balanced. Constructed to AMCA 99.

1.4.3 Sound ratings: comply with AMCA 301, tested to AMCA 300. Unit shall bear AMCA certified sound rating seal.

1.4.4 Performance ratings: based on tests performed in accordance with ANSI/AMCA 210, unit to bear AMCA certified rating seal.

1.4.5 Bearings: sealed lifetime oilite ball bearings, heavy duty grease lubricated ball or roller bearings of self-aligning type with oil retaining, dust excluding seals and a certified minimum rated L10 life of 100,000 hours.

1.5 SUBMITTALS

1.5.1 Product Data:

1.5.1.1 Submit manufacturer's printed product literature, specifications and datasheet in accordance with Section 01 33 00 - Submittal Procedures. Include product characteristics, performance criteria, and limitations.

1.5.1.1.1 Submit two copies of Workplace Hazardous Materials Information System (WHMIS) Safety Data Sheets (SDS) in accordance with Section 01 33 00 - Submittal Procedures.

1.5.2 Shop Drawings:

1.5.2.1 Submit shop drawings in accordance with Section 01 33 00 - Submittal Procedures.

1.5.2.2 Include:

1.5.2.2.1 Fan performance curves showing specified point of operation.

1.5.2.2.2 Sound rating data.

1.5.2.2.3 Installation procedures.

1.5.3 Quality assurance submittals: submit following in accordance with Section 01 33 00 - Submittal Procedures.

1.5.3.1 Certificates: submit certificates signed by manufacturer certifying that materials comply with specified performance characteristics and physical properties.

1.5.3.2 Instructions: submit manufacturer's installation instructions.

1.5.4 Closeout Submittals

1.5.4.1 Provide operation and maintenance data for incorporation into manual specified in Section 01 78 00 - Closeout Submittals.

1.6 QUALITY ASSURANCE

1.6.1 Health and Safety Requirements: do construction occupational health and safety in accordance with - Health and Safety Requirements.

1.7 DELIVERY, STORAGE, AND HANDLING

1.7.1 Packing, shipping, handling and unloading:

1.7.1.1 Deliver, store and handle in accordance with Section 01 61 00 - Common Product Requirements.

1.7.1.2 Deliver, store and handle materials in accordance with manufacturer's written instructions.

1.7.2 Waste Management and Disposal:

- 1.7.2.1 Construction/Demolition Waste Management and Disposal:
separate waste materials for reuse and recycling in accordance
with Section 01 74 21 - Construction/Demolition Waste
Management and Disposal.

1.8 MAINTENANCE

- 1.8.1 Extra Materials:
1.8.1.1 Provide maintenance materials in accordance with Section
01 78 00 - Closeout Submittals.
- 1.8.2 Furnish list of individual manufacturer's recommended spare parts for
equipment, include:
1.8.2.1 Bearings and seals.
1.8.2.2 Belts.
1.8.2.3 Addresses of suppliers.
1.8.2.4 List of specialized tools necessary for adjusting, repairing or
replacing.

2. PART2 PRODUCTS

2.1 FANS GENERAL

- 2.1.1 Capacity: flow rate, static pressure Pa, r/min, bhp, model and size and
sound ratings as indicated on schedule.
- 2.1.2 Statically and dynamically balanced. Constructed in conformity with
AMCA 99.
- 2.1.3 Sound ratings: comply with AMCA 301, tested to AMCA 300.
- 2.1.4 Performance ratings: based on tests performed in accordance with
ANSI/ASHRAE 51/AMCA 210.
- 2.1.5 Bearings: sealed lifetime ball bearings or heavy duty grease lubricated
ball or roller bearings of self aligning type with oil retaining, dust
excluding seals and a certified minimum rated life to ABMA L10 of
100,000 h.

2.2 ROOF EXHAUSTERS

- 2.2.1 Centrifugal V belt or direct driven.
2.2.1.1 Housings: spun aluminum complete with resilient mounted
motor and fan.
2.2.1.2 Impeller: aluminum non-overloading.
2.2.1.3 Adjustable motor sheave.
2.2.1.4 12 mm mesh 2.0 mm dia aluminum birdscreen.
2.2.1.5 Motorized gasketed insulated aluminum back draft dampers to
Section 23 33 15 - Dampers - Operating.
2.2.1.6 Weatherproof disconnect switch within fan housing.
2.2.1.7 Roof curb, 350 mm high, continuous curb gaskets, cadmium
plated or stainless-steel securing bolts and screws, and special
mated sound insulating 350 mm high curbs where indicated.
Hinge curb plate for access to internals for maintenance.
- 2.2.2 Eisenheiss coated wheel and up blast discharge for fume hood service
with motor out of air stream.
- 2.2.3 Sound curbs: of same manufacturer as fan and built to suit model
specified.
2.2.3.1 Double baffle and self-flashing type. Required decibel sound
attenuation spectrum:

Frequency	1	2	3	4	5	6	7	8
Octave Band								
dB Attenuation	3	5	11	16	22	20	17	13

2.2.3.2 Pressure loss through curbs: 37 Pa max at rated L/s.

2.2.4 Two speed fan motors: two windings or split windings with speeds of approximately 1800 RPM high and 900 RPM.

2.3 WALL EXHAUSTERS

2.3.1 Centrifugal backward inclined fan units, V belt or direct driven.

2.3.1.1 Spun aluminum housings, complete with resilient mounted motor and fan.

2.3.1.2 12 mm mesh 2.0 mm dia aluminum birdscreen.

2.3.1.3 Motorized gasketed insulation aluminum back draft dampers to Section 23 33 15 – Dampers - Operating.

2.3.1.4 Weatherproof disconnect switch within fan housing.

2.3.1.5 Cadmium plated or stainless steel securing bolts and screws.

2.3.2 Housings:

2.3.2.1 Provide with rubber or neoprene grommets for wiring passages, integral attachment collar, or angle ring mounted to mating flanged wall sleeve with full gasketing.

2.3.2.2 Discharge pattern: away from building.

2.3.3 Two speed motors: two windings or with speeds of approximately 1800 r/min high and 900 r/min low as indicated.

2.4 ROOF EXHAUSTERS FOR GREASE EXHAUST

2.4.1 Entire fan housing, cowl and discharge 16 gauge cold rolled steel, continuously welded and liquid tight to NFPA 96 requirements.

2.4.2 Unit complete with 1.6 mm pitched where indicated, roof curb, cold rolled steel shipped separately for field installation, discharger clearance 1000 mm above roof.

2.4.3 The exhaust duct collar 25 mm insulated double skin, 1.6 mm inner skin, 0.9 mm outer skin, cold rolled steel, all welded. Extend 305 mm minimum below the roof line and have a 38 mm flanged connection for welding or bolting to the duct system. Minimum clearance from duct collar to combustible roof opening 74 mm as per U.L.C. approvals.

2.4.4 The fan wheel all welded, statically and dynamically balanced at factory, with single inlet and backward inclined blades to provide non-overloading characteristics and minimum noise level. Bearings grease lubricated, heavy duty self-aligning flange type, mounted outside of air stream on oversized, polished steel shaft.

2.4.5 Unit complete with smoothly curved inlet venturi, to create a stream-lined air flow into the fan wheel.

2.4.6 Complete unit factory primed and painted, ready for outside installation.

2.4.7 Fan to have electrical disconnect switch, supplied wired to the fan motor and an electrical conduit sleeve that runs the complete length of the duct collar. High temperature wire provided in conduit to point approximately 152 mm below the duct collar.

2.4.8 Adjustable pitch (1 or 2 groove) pulleys provided factory set at proper operating speed from motors up to the 5 H.P., fixed pulleys provided over 5 HP.

2.4.9 Fan Underwriter Laboratories approved as a power roof ventilator for kitchen exhaust systems

2.4.10 Complete with gravity back draft damper located at the fan discharge.

3. PART3 EXECUTION

3.1 MANUFACTURER'S INSTRUCTIONS

- 3.1.1 Compliance: comply with manufacturer's written recommendations or specifications, including product technical bulletins, handling, storage and installation instructions, and datasheet.

3.2 INSTALLATION

- 3.2.1 Install in accordance with manufacturer's instructions.
- 3.2.2 Install fans for grease exhaust fans in accordance with NFPA 96.

3.3 CLEANING

- 3.3.1 Proceed in accordance with Section 01 74 00 - Cleaning.
- 3.3.2 Upon completion and verification of performance of installation, remove surplus materials, excess materials, rubbish, tools and equipment.

3.4 COMMISSIONING

- 3.4.1 Commissioning in accordance with Section 01 91 13.13 - Commissioning (Cx) Requirements.

END OF SECTION

SECTION 233517:

GENERATOR EXHAUST SYSTEMS

1. PART1 GENERAL
 - 1.1 RELATED WORK
 - 1.1.1 Do the work in accordance with section 23 05 17 – Pipe Welding and local authority having jurisdiction except where specified otherwise.
 - 1.1.2 Section 22 07 19 – Plumbing Piping Insulation.
 - 1.1.3 Section 23 05 29 – Hangers and supports for HVAC Piping and Equipment.
 - 1.2 PRODUCT DATA
 - 1.2.1 Submit product drawings and product data in accordance with Section 01 33 00 - Submittal Procedures.
 - 1.2.2 Indicate dimensions, construction details and materials.
2. PART2 PRODUCTS
 - 2.1 DIESEL EXHAUST SYSTEM
 - 2.1.1 Provide exhaust system for new diesel generator. Exhaust systems shall be complete with all fittings and accessories as required for a complete installation.
 - 2.1.2 Diesel generator shall be supplied and installed by Electrical Division except as otherwise indicated. Exhaust silencer and flexible exhaust hose shall be supplied by Electrical Division, and installed by this contractor. Coordinate installation with Electrical Division and diesel manufacturer.
 - 2.1.3 Maximum back pressure of the silencer, exhaust flex and piping not to exceed the diesel manufacturer's recommendations.
 - 2.1.4 Exhaust piping shall be schedule 80 steel ASTM A53 or A106 c/w butt welded fittings.
3. PART3 EXECUTION
 - 3.1 INSTALLATION
 - 3.1.1 Install in accordance with manufacturer's instructions and as specified.
 - 3.2 DIESEL EXHAUST SYSTEMS
 - 3.2.1 Installation to be in accordance with manufacturer's recommendations.
 - 3.2.2 Coordinate exhaust pipe sizes and connection to diesels with Electrical Division.
 - 3.2.3 Insulate pipe and muffler with type A-2 insulation.
 - 3.3 COMMISSIONING
 - 3.3.1 After start-up, test and adjust to suit site conditions.

END OF SECTION

SECTION 233600:**AIR TERMINAL UNITS****1. PART1 GENERAL****1.1 RELATED SECTIONS**

- 1.1.1 Section 01 33 00 – Submittal Procedures.
- 1.1.2 Section 01 45 00 – Quality Control.
- 1.1.3 Section 01 74 21 – Construction/Demolition Waste Submittal and Disposal.
- 1.1.4 Section 01 78 00 – Closeout Submittals.
- 1.1.5 Section 23 32 48 – Acoustical Air Plenums.

1.2 REFERENCES

- 1.2.1 American National Standards Institute (ANSI)
 - 1.2.1.1 ANSI/AMCA 210, Laboratory Methods of Testing Fans for Aerodynamic Performance Rating.
 - 1.2.1.2 ANSI/NFPA 90A, Standard for the Installation of Air Conditioning and Ventilating Systems.
- 1.2.2 American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE)
 - 1.2.2.1 ASHRAE 130, Methods of Testing for Rating Ducted Air Terminal Units.
- 1.2.3 International Organization of Standardization (ISO)
 - 1.2.3.1 ISO 3741, Acoustics-Determination of Sound Power Levels of Noise Sources Using Sound Pressure - Precision Methods for Reverberation Rooms.
- 1.2.4 Underwriter's Laboratories (UL)
 - 1.2.4.1 UL 181, Factory-Made Air Ducts and Air Connectors.

1.3 SYSTEM DESCRIPTION

- 1.3.1 Performance Requirements:
 - 1.3.1.1 Catalogued or published ratings for manufactured items: obtained from tests carried out by manufacturer or those ordered by manufacturer from certified ADC (Air Diffusion Council) testing agency signifying adherence to codes and standards.

1.4 SUBMITTALS

- 1.4.1 Product Data:
 - 1.4.1.1 Submit manufacturer's printed product literature, specifications and datasheet in accordance with Section 01 33 00 –Submittal Procedures. Include product characteristics, performance criteria, and limitations.
 - 1.4.1.1.1 Submit two copies of Workplace Hazardous Materials Information System (WHMIS) Safety Data Sheets (SDS) in accordance with Section 01 33 00 – Submittal Procedures.
 - 1.4.1.2 Test data: to ANSI/AMCA 210.
 - 1.4.1.2.1 Submit published test data on DIN (Direct Internal Noise), in accordance with ISO 3741 made by independent testing agency for 0, 2.5 and 6 m/s branch velocity or inlet velocity.
 - 1.4.1.2.2 Sound power level with minimum inlet pressure of 0.25, 0.5, 1, and 1.5 kPa in accordance with ISO 3741 for 2nd through 7th octave band, also made by independent testing agency.
 - 1.4.1.2.3 Pressure loss through silencer shall not exceed 60% of inlet velocity pressure maximum.

- 1.4.2 Shop Drawings:
 - 1.4.2.1 Submit shop drawing in accordance with Section 01 33 00 – Submittal Procedures.
 - 1.4.2.2 Indicate the following:
 - 1.4.2.2.1 Capacity.
 - 1.4.2.2.2 Pressure drop.
 - 1.4.2.2.3 Noise rating.
 - 1.4.2.2.4 Leakage.
 - 1.4.2.2.5 Dimensions.
 - 1.4.3 Quality assurance submittals: submit following in accordance with Section 01 33 00 – Submittal Procedures.
 - 1.4.3.1 Certificates: submit certificates signed by manufacturer certifying that materials comply with specified performance characteristics and physical properties.
 - 1.4.3.2 Instructions: submit manufacturer's installation instructions.
 - 1.4.4 Closeout Submittals:
 - 1.4.4.1 Provide maintenance data for incorporation into manual specified in Section 01 78 00 – Closeout Submittals.
- 1.5 QUALITY ASSURANCE
 - 1.5.1 Health and Safety Requirements: do construction occupational health and safety in accordance with– Health and Safety Requirements.
- 1.6 DELIVERY, STORAGE, AND HANDLING
 - 1.6.1 Packing, shipping, handling and unloading:
 - 1.6.1.1 Deliver store and handle in accordance with Section 01 61 00 – Common Product Requirements.
 - 1.6.1.2 Deliver, store and handle materials in accordance with manufacturer's written instructions.
 - 1.6.2 Waste Management and Disposal:
 - 1.6.2.1 Construction/Demolition Waste Management and Disposal: separate waste materials for reuse and recycling in accordance with Section 01 74 21 – Construction/Demolition Waste Management and Disposal.
- 1.7 MAINTENANCE
 - 1.7.1 Extra Materials:
 - 1.7.1.1 Provide maintenance materials in accordance with Section 01 78 00 – Closeout Submittals.
 - 1.7.1.2 Furnish list of individual manufacturer's recommended spare parts for equipment. Include:
 - 1.7.1.2.1 Bearings and seals.
 - 1.7.1.2.2 Addresses of suppliers.
 - 1.7.1.2.3 List of specialized tools necessary for adjusting, repairing or replacing.
- 2. PART2 PRODUCTS
 - 2.1 MANUFACTURED UNITS
 - 2.1.1 Terminal units of the same type to be product of one manufacturer.
 - 2.2 VARIABLE VOLUME BOXES
 - 2.2.1 Pressure independent factory reset to air flow between minimum and maximum air volume.
 - 2.2.2 Sizes, capacities, differential pressures and sound ratings: as indicated in schedule.
 - 2.2.3 Differential pressure not to exceed 25 Pa at inlet air velocity of 10 m/s.

- 2.2.4 Sound ratings of assembly not to exceed 35 NC at 750 Pa. Use sound attenuator if necessary to achieve rating.
 - 2.2.5 Complete with:
 - 2.2.5.1 Operator and controller: as specified under Section 25 30 02 – EMCS: Field Control Devices.
 - 2.2.5.2 Sound attenuator: as indicated or as specified in Section 23 32 48 – Acoustical Air Plenums.
 - 2.2.5.3 Multiport outlet adapter: as indicated.
 - 2.2.5.4 Reheat coil: as indicated.
 - 2.2.6 Minimum 35 kPa reset span for pneumatic controllers.
 - 2.2.7 Adjustable reset start point.
 - 2.2.8 Operator to be factory or field mounted and calibrated where indicated.
 - 2.2.8.1 Gauge taps for balancing with standard pressure gauge.
 - 2.2.8.2 Controller to have adjustable flow settings.
 - 2.2.9 Casing: constructed of 0.75 mm thick galvanized steel, internally lined with 25 mm, 0.7 kg density fibrous glass, to UL181 and ANSI/NFPA 90A. Mount control components inside protective metal shroud.
 - 2.2.10 Damper: galvanized steel with peripheral gasket and self-lubricating bearings. Air leakage past closed damper not to exceed 2% of nominal rating at 750 Pa inlet static pressure, in accordance with Air Diffusion Council test procedure.
- 2.3 CONSTANT VOLUME BYPASS BOXES**
- 2.3.1 Maintains space condition by bypassing supply air to return air.
 - 2.3.2 Sizes, capacities, pressure loss, and discharge sound pressure level: as indicated.
 - 2.3.3 Discharge sound pressure level: to be less than 35 NC.
 - 2.3.4 Complete with:
 - 2.3.4.1 Bypass collar for connection to return air duct.
 - 2.3.4.2 Minimum air volume stop.
 - 2.3.4.3 Controller and operator as specified under 25 30 02 –EMCS: Field Control Devices.
 - 2.3.4.4 Reheat coil as indicated.
 - 2.3.4.5 Manual balancing damper.
 - 2.3.4.6 Multi-port outlets.
 - 2.3.4.7 Sound attenuator: as indicated.
 - 2.3.5 Casing: constructed of 0.75 mm thick galvanized steel, internally lined with 25 mm, 0.7 kg density fibrous glass, to UL 181 and ANSI/NFPA 90A. Mount control components inside protective metal shroud.
 - 2.3.6 Damper: galvanized steel with peripheral gasket and self lubricating bearings. Air leakage past closed damper not to exceed 2% of nominal rating at 750 Pa inlet static pressure, in accordance with Air Diffusion Council test procedure.
 - 2.3.7 Sequence of operation as specified under Section 25 90 01 – EMCS: Site Requirements, Applications and Systems Sequence of Operations.
- 2.4 FAN POWERED BOXES**
- 2.4.1 General:
 - 2.4.1.1 Primary air assembly, pressure independent with reset to any air flow between minimum and maximum air volume as indicated.
 - 2.4.1.2 Sound ratings of assembly not to exceed 35 NC at 750 Pa. on discharge.
 - 2.4.1.3 Field calibration and readjustment of air volume to be as follows:

- 2.4.1.3.1 Gauge tops for balancing with standard pressure gauge and
 - 2.4.1.3.2 Adjustable flow settings.
 - 2.4.1.4 Casing: constructed of heavy gauge, galvanized steel, internally lined with 25 mm, 0.7 kg density fibrous glass, to UL181 and ANSI/NFPA 90A. Mount control components inside protective metal shroud.
 - 2.4.1.5 Damper: galvanized steel with peripheral gasket and self lubricating bearings. Air leakage past closed damper not to exceed 2% of nominal rating at 750 Pa inlet static pressure, in accordance with Air Diffusion Council test procedure.
 - 2.4.1.6 Complete with:
 - 2.4.1.6.1 Sound attenuator: as indicated
 - 2.4.1.6.2 Reheat coil as indicated.
 - 2.4.1.6.3 Multiport outlet adapter: as indicated.
 - 2.4.2 Fan section.
 - 2.4.2.1 CSA certified.
 - 2.4.2.2 Forward curved, centrifugal, direct drive, permanently lubricated motor, internally suspended and isolated from casing on rubber-in-shear isolators complete with access panel.
 - 2.4.2.3 Fan controls to be sealed from primary air flow.
 - 2.4.2.4 Electrical characteristics: 120/1/60.
 - 2.4.3 Sequence of operation as specified under Section 25 90 01 – EMCS: Site Requirements, Applications and Systems Sequence of Operations.
3. PART3 EXECUTION
- 3.1 MANUFACTURER'S INSTRUCTIONS
- 3.1.1 Compliance: comply with manufacturer's written recommendations or specifications, including product technical bulletins, handling, storage and installation instructions, and datasheet.
- 3.2 INSTALLATION
- 3.2.1 Install in accordance with manufacturers recommendations.
 - 3.2.2 Support independently of ductwork.
 - 3.2.3 Install with at least 1000 mm of rigid inlet ducting and minimum of four duct diameters of straight inlet duct, same size as inlet.
 - 3.2.4 Locate so that controls, dampers and access panels are easily accessible.
- 3.3 CLEANING
- 3.3.1 Proceed in accordance with Section 01 74 00 - Cleaning.
 - 3.3.2 Upon completion and verification of performance of installation, remove surplus materials, excess materials, rubbish, tools and equipment.
- 3.4 COMMISSIONING
- 3.4.1 Commission in accordance with Section 01 91 13.13 – Commissioning (Cx) Requirements.

END OF SECTION

SECTION 233713:**DIFFUSERS, REGISTERS AND GRILLES****1. PART1 GENERAL****1.1 SUMMARY****1.1.1 Section includes:**

1.1.1.1 Supply, return and exhaust grilles and registers, diffusers and linear grilles, for commercial and residential use.

1.2 RELATED SECTIONS

1.2.1 Section 01 33 00 - Submittal Procedures.

1.2.2 Section 01 74 21 - Construction/Demolition Waste Management and Disposal.

1.2.3 Section 01 78 00 - Closeout Submittals.

1.3 REFERENCES

1.3.1 American Society of Heating Refrigerating and Air-Conditioning Engineers (ASHRAE).

1.3.1.1 ASHRAE 70, Method of Testing for Rating the Performance of Air Outlets and Inlets.

1.4 SYSTEM DESCRIPTION**1.4.1 Performance requirements:**

1.4.1.1 Catalogued or published ratings for manufactured items: obtained from tests carried out by manufacturer or those ordered by manufacturer from independent testing agency signifying adherence to codes and standards.

1.5 SUBMITTALS**1.5.1 Product Data:**

1.5.1.1 Submit manufacturer's printed product literature, specifications and datasheet in accordance with Section 01 33 00 - Submittal Procedures. Include product characteristics, performance criteria, and limitations.

1.5.1.1.1 Submit two copies of Workplace Hazardous Materials Information System (WHMIS) Safety Data Sheets (SDS) in accordance with Section 01 33 00 - Submittal Procedures.

1.5.1.1.2 Indicate following:

1.5.1.1.2.1 Capacity

1.5.1.1.2.2 Throw and terminal velocity

1.5.1.1.2.3 Noise criteria

1.5.1.1.2.4 Pressure drops

1.5.1.1.2.5 Neck velocity

1.5.2 Quality assurance submittals: submit following in accordance with Section 01 33 00 - Submittal Procedures.

1.5.2.1 Certificates: submit certificates signed by manufacturer certifying that materials comply with specified performance characteristics and physical properties.

1.5.2.2 Instructions: submit manufacturer's installation instructions.

1.6 QUALITY ASSURANCE

1.6.1 Health and Safety Requirements: do construction occupational health and safety in accordance with - Health and Safety Requirements.

1.7 DELIVERY, STORAGE, AND HANDLING**1.7.1 Packing, shipping, handling and unloading:**

1.7.1.1 Deliver, store and handle in accordance with Section 01 61 00 - Common Product Requirements.

- 1.7.1.2 Deliver, store and handle materials in accordance with manufacturer's written instructions.
- 1.7.2 Waste Management and Disposal:
 - 1.7.2.1 Construction/Demolition Waste Management and Disposal: separate waste materials for reuse and recycling in accordance with Section 01 74 21 - Construction/Demolition Waste Management and Disposal.
- 2. PART 2 PRODUCTS
 - 2.1 GENERAL
 - 2.1.1 To meet capacity, pressure drop, terminal velocity, throw, noise level, neck velocity.
 - 2.1.2 Frames:
 - 2.1.2.1 Full perimeter gaskets.
 - 2.1.2.2 Plaster frames where set into plaster or gypsum board.
 - 2.1.2.3 Concealed fasteners.
 - 2.1.3 Concealed manual volume control damper operators as indicated.
 - 2.1.4 Colour: standard or as directed by Owner.
 - 2.2 MANUFACTURED UNITS
 - 2.2.1 Grilles, registers and diffusers of same generic type to be product of one manufacturer.
 - 2.3 SUPPLY GRILLES AND REGISTERS
 - 2.3.1 See Schedule.
 - 2.4 RETURN AND EXHAUST GRILLES AND REGISTERS
 - 2.4.1 See Schedule.
 - 2.5 DIFFUSERS
 - 2.5.1 See Schedule.
 - 2.6 LINEAR GRILLES
 - 2.6.1 See Schedule.
- 3. PART3 EXECUTION
 - 3.1 MANUFACTURER'S INSTRUCTIONS
 - 3.1.1 Compliance: comply with manufacturer's written recommendations or specifications, including product technical bulletins, handling, storage and installation instructions, and datasheet.
 - 3.2 INSTALLATION
 - 3.2.1 Install in accordance with manufacturers instructions.
 - 3.2.2 Install with flat head stainless steel or cadmium plated screws in countersunk holes where fastenings are visible.
 - 3.2.3 Bolt grilles, registers and diffusers, in place, in gymnasium and similar game rooms.
 - 3.2.4 Provide concealed safety chain on each grille, register and diffuser in gymnasium and similar game rooms and elsewhere.
 - 3.3 CLEANING
 - 3.3.1 Proceed in accordance with Section 01 74 00 - Cleaning.
 - 3.3.2 Upon completion and verification of performance of installation, remove surplus materials, excess materials, rubbish, tools and equipment.

END OF SECTION

SECTION 233720:

LOUVERS, INTAKES AND VENTS

1. PART1 GENERAL

1.1 SUMMARY

1.1.1 Section Includes:

1.1.1.1 Mechanical louvers; intakes; vents; and reinforcement and bracing for air vents, intakes and gooseneck hoods.

1.2 RELATED SECTIONS

1.2.1 Section 01 33 00 - Submittal Procedures.

1.2.2 Section 01 74 21 - Construction/Demolition Waste Management and Disposal.

1.3 REFERENCES

1.3.1 Air Movement and Control Association (AMCA)

1.3.1.1 AMCA 540, Test Method for Louvres Impacted by Wind Borne Debris.

1.3.1.2 AMCA 550, Test Method for High Velocity Wind Driven Rain Resistant Louvres.

1.3.2 American National Standards Institute (ANSI)/ National Fire Protection Association (NFPA)

1.3.2.1 ANSI/NFPA 96, Standard for Ventilation Control and Fire Protection of Commercial Cooking Operations.

1.3.3 American Society for Testing and Materials International (ASTM)

1.3.3.1 ASTM E 90, Standard Test Method for Laboratory Measurement of Airborne Sound Transmission Loss of Building Partitions and Elements.

1.3.4 Sheet Metal and Air Conditioning Contractors' National Association (SMACNA)

1.3.5 Society of Automotive Engineers (SAE)

1.4 SYSTEM DESCRIPTION

1.4.1 Performance Requirements:

1.4.1.1 Catalogued or published ratings for manufactured items: obtained from tests carried out by manufacturer or those ordered by manufacturer from independent testing agency signifying adherence to codes and standards.

1.5 SUBMITTALS

1.5.1 Product Data:

1.5.1.1 Submit manufacturer's printed product literature, specifications and datasheet in accordance with Section 01 33 00 - Submittal Procedures. Include product characteristics, performance criteria, and limitations.

1.5.1.1.1 Submit two copies of Workplace Hazardous Materials Information System (WHMIS) Safety Data Sheets (SDS)

- in accordance with Section 01 33 00 - Submittal Procedures.
 - 1.5.1.1.2 Indicate following:
 - 1.5.1.1.2.1 Pressure drop.
 - 1.5.1.1.2.2 Face area.
 - 1.5.1.1.2.3 Free area.
 - 1.5.1.1.2.4 Dimensions
 - 1.5.1.2 Quality assurance submittals: submit following in accordance with Section 01 33 00 - Submittal Procedures.
 - 1.5.1.2.1 Certificates: submit certificates signed by manufacturer certifying that materials comply with specified performance characteristics and physical properties.
 - 1.5.1.2.2 Instructions: submit manufacturer's installation instructions.
 - 1.5.1.3 Test Reports:
 - 1.5.1.3.1 Submit certified data from independent laboratory substantiating acoustic and aerodynamic performance to ASTM E 90.
- 1.6 QUALITY ASSURANCE
 - 1.6.1 Health and Safety Requirements: do construction occupational health and safety in accordance with - Health and Safety Requirements.
- 1.7 DELIVERY, STORAGE, AND HANDLING
 - 1.7.1 Packing, shipping, handling and unloading:
 - 1.7.1.1 Deliver, store and handle in accordance with Section 01 61 00 - Common Product Requirements.
 - 1.7.1.2 Deliver, store and handle materials in accordance with manufacturer's written instructions.
 - 1.7.2 Waste Management and Disposal:
 - 1.7.2.1 Construction/Demolition Waste Management and Disposal: separate waste materials for reuse and recycling in accordance with Section 01 74 21 - Construction/Demolition Waste Management and Disposal.
- 2. PART2 PRODUCTS
 - 2.1 GRAVITY ROOF OUTSIDE AIR INTAKES AND RELIEF VENTS
 - 2.1.1 Factory manufactured aluminum hinged at curb line.
 - 2.1.1.1 Complete with integral birdscreen of 2.7 mm diam 12 mm mesh aluminum wire.
 - 2.1.1.2 Vertical or horizontal backdraft dampers on four faces.
 - 2.1.1.3 Maximum throat velocity: 3.3 m/s intake.
 - 2.1.1.4 Maximum loss through unit: 15 Pa exhaust static pressure.
 - 2.1.1.5 Maximum velocity through damper area: 1.5 m/s.
 - 2.1.1.6 Shape: as indicated.
 - 2.2 GOOSENECK HOODS
 - 2.2.1 Thickness: to SMACNA.
 - 2.2.1.1 Kitchen: to ANSI/NFPA 96.
 - 2.2.1.2 Elsewhere: to SMACNA.
 - 2.2.2 Fabrication: to SMACNA.
 - 2.2.2.1 Kitchen: to ANSI/NFPA 96.
 - 2.2.2.2 Elsewhere: to SMACNA.
 - 2.2.3 Joints: to SMACNA or proprietary manufactured duct joint. Proprietary manufactured flanged duct joint shall be considered to be a class A seal.

- 2.2.4 Supports: as indicated.
- 2.2.5 Complete with integral birdscreen of 2.7 mm diameter aluminum wire. Use 12 mm mesh on exhaust and intake.
- 2.2.6 Horizontal backdraft dampers.
- 2.3 FIXED LOUVRES - ALUMINUM
 - 2.3.1 Construction: welded with exposed joints ground flush and smooth.
 - 2.3.2 Material: extruded aluminum alloy 6063-T5.
 - 2.3.3 Blade: drainable, stormproof pattern with centre watershed in blade, reinforcing bosses and maximum blade length of 1500 mm.
 - 2.3.4 Frame, head, sill and jamb: 100 mm deep one piece extruded aluminum, minimum 3 mm thick with approved caulking slot, integral to unit. Flanged frame or flush frame as indicated.
 - 2.3.5 Mullions: at 1500 mm maximum centres.
 - 2.3.6 Fastenings: stainless steel with nuts and resilient neoprene washers between aluminum and head of bolt, or between nut, ss washer and aluminum body.
 - 2.3.7 Screen: 12 mm on exhaust and intake mesh, 2.0 mm diameter wire aluminum or galvanized birdscreen on inside face of louvres in formed U-frame.
 - 2.3.8 Finish: factory applied enamel, or anodized as indicated. Colour: to Owner's approval.
- 3. PART3 EXECUTION
 - 3.1 MANUFACTURER'S INSTRUCTIONS
 - 3.1.1 Compliance: comply with manufacturer's written recommendations or specifications, including product technical bulletins, handling, storage and installation instructions, and datasheet.
 - 3.2 INSTALLATION
 - 3.2.1 In accordance with manufacturer's and SMACNA recommendations.
 - 3.2.2 Reinforce and brace as indicated.
 - 3.2.3 Anchor securely into opening. Seal with caulking around to ensure weather tightness.
 - 3.3 CLEANING
 - 3.3.1 Proceed in accordance with Section 01 74 00 - Cleaning.
 - 3.3.2 Upon completion and verification of performance of installation, remove surplus materials, excess materials, rubbish, tools and equipment.

END OF SECTION

SECTION 234000:**HVAC AIR CLEANING DEVICES****1. PART 1 GENERAL****1.1 SUMMARY****1.1.1 Section Includes:**

- 1.1.1.1 Filters and filter gauges for various types of mechanical air handling equipment.

1.2 RELATED SECTIONS:

- 1.2.1 Section 01 33 00 - Submittal Procedures.
- 1.2.2 Section 01 74 21 - Construction/Demolition Waste Management and Disposal.
- 1.2.3 Section 23 73 00.13 - Air Handling - Built-up.
- 1.2.4 Section 23 73 00.16 - Air Handling Units - Packaged.
- 1.2.5 Section 23 74 00 - Packaged Outdoor HVAC Equipment.

1.3 REFERENCES

- 1.3.1 American National Standards Institute/National Fire Prevention Association (ANSI/NFPA)
 - 1.3.1.1 ANSI/NFPA 96, Ventilation Control and Fire Protection of Commercial Cooking Operations.
- 1.3.2 American Society of Heating, Refrigeration and Air-Conditioning Engineers (ASHRAE)
 - 1.3.2.1 ASHRAE 52.1, Gravimetric And Dust Spot for Testing Air-Cleaning Devices Used in General Ventilation for Removing Particulate Matter (ANSI Approved).
 - 1.3.2.2 ASHRAE 52.2, Method of Testing General Ventilation Air Cleaning Devices for Removal Efficiency by Particle Size.
 - 1.3.2.3 ASHRAE 145.1, Laboratory Test Method for Assessing the Performance of Gas-Phase Air Cleaning Systems: Loose Granular Media.
 - 1.3.2.4 ASHRAE 145.2, Laboratory Test Method for Assessing the Performance of Gas-Phase Air Cleaning Systems: Air Cleaning Devices.
- 1.3.3 Underwriters' Laboratories of Canada (ULC)
 - 1.3.3.1 ULC-S111, Standard Method of Fire Tests for Air Filter Units.
 - 1.3.3.2 ULC-S649, Exhaust Hoods and Related Controls for Commercial and Institutional Kitchens.

1.4 SUBMITTALS**1.4.1 Product Data:**

- 1.4.1.1 Submit manufacturer's printed product literature, specifications and datasheet in accordance with Section 01 33 00 - Submittal Procedures. Include product characteristics, performance criteria, and limitations.
 - 1.4.1.1.1 Submit two copies of Workplace Hazardous Materials Information System (WHMIS) Safety Data Sheets (SDS) in accordance with Section 01 33 00 - Submittal Procedures.

1.4.2 Shop Drawings:

- 1.4.2.1 Submit shop drawings in accordance with Section 01 33 00 - Submittal Procedures.
 - 1.4.2.1.1 Indicate following:
 - 1.4.2.1.1.1 Pressure drop.
 - 1.4.2.1.1.2 Installation procedures.

- 1.4.3 Quality assurance submittals: submit following in accordance with Section 01 33 00 - Submittal Procedures.
 - 1.4.3.1 Certificates: submit certificates signed by manufacturer certifying that materials comply with specified performance characteristics and physical properties.
 - 1.4.3.2 Instructions: submit manufacturer's installation instructions.
- 1.4.4 Closeout Submittals
 - 1.4.4.1 Provide maintenance data for incorporation into manual specified in Section 01 78 00 - Closeout Submittals.
- 1.5 QUALITY ASSURANCE
 - 1.5.1 Health and Safety Requirements: do construction occupational health and safety in accordance with - Health and Safety Requirements.
- 1.6 DELIVERY, STORAGE, AND HANDLING
 - 1.6.1 Packing, shipping, handling and unloading:
 - 1.6.1.1 Deliver, store and handle in accordance with Section 01 61 00 - Common Product Requirements.
 - 1.6.1.2 Deliver, store and handle materials in accordance with manufacturer's written instructions.
 - 1.6.2 Waste Management and Disposal:
 - 1.6.2.1 Construction/Demolition Waste Management and Disposal: separate waste materials for reuse and recycling in accordance with Section 01 74 21 - Construction/Demolition Waste Management and Disposal.
- 1.7 MAINTENANCE
 - 1.7.1 Extra Materials:
 - 1.7.1.1 Provide maintenance materials in accordance with Section 01 78 00 - Closeout Submittals.
 - 1.7.1.2 Furnish list of individual manufacturer's recommended spare parts for equipment such as frames and filters, addresses of suppliers, list of specialized tools necessary for adjusting, repairing or replacing for inclusion in operating manual.
 - 1.7.1.3 Spare filters: in addition to filters installed immediately prior to acceptance by Owner, supply one (1) complete set of filters for each filter unit or filter bank in accordance with section 01 78 00 - Closeout Submittals
- 2. PART2 PRODUCTS
 - 2.1 GENERAL
 - 2.1.1 Media: suitable for air at 100% RH and air temperatures between minus 40 and 50 °C.
 - 2.1.2 Number of units, size as recommended by manufacturer and thickness of panels, overall dimensions of filter bank, configuration and capacities: as indicated.
 - 2.1.3 Pressure drop when clean and dirty, sizes and thickness: as indicated on schedule.
 - 2.2 ACCESSORIES
 - 2.2.1 Holding frames: permanent "T" section or channel section construction of galvanized steel or same material as casing/hood, 1.6 mm thick, except where specified otherwise.
 - 2.2.2 Seals: to ensure leakproof operation.
 - 2.2.3 Blank-off plates: as required, to fit all openings and of same material as holding frames.

- 2.2.4 Access and servicing: through doors/panels on each side and/or from upstream face of filter bank.
- 2.3 FIBROUS GLASS PANEL FILTERS
 - 2.3.1 Disposable fibrous glass media: to ASHRAE 52.2 with adhesive.
 - 2.3.2 Holding frame: 1.2 mm minimum thick galvanized steel with 3.0 mm diam hinged wire mesh screen.
 - 2.3.3 Performance: minimum average synthetic dust weight arrestance 70 %.
 - 2.3.4 Fire rated: to ULC -S111.
 - 2.3.5 Nominal thickness: 50 mm.
- 2.4 GREASE FILTERS
 - 2.4.1 Media: washable, 50 mm thick: to ULC- S649 and ANSI/NFPA 96.
 - 2.4.2 Holding frame: 1.0 mm thick stainless steel V or inclined as indicated.
 - 2.4.3 Stainless steel blank-off plates.
 - 2.4.4 Individual, removable drip trays with handles.
- 2.5 CARTRIDGE TYPE FILTERS, 80-85 % EFFICIENCY
 - 2.5.1 Media: deep pleated, disposable, high efficiency, to ASHRAE 52.2.
 - 2.5.2 Holding frame: galvanized steel with bracing.
 - 2.5.3 Media support: welded wire grid.
 - 2.5.4 Performance: average atmospheric dust spot efficiency 80-85 % to ASHRAE 52.2.
 - 2.5.5 Fire rated: to ULC -S111.
- 2.6 CARTRIDGE TYPE FILTERS 95 %EFFICIENCY
 - 2.6.1 Media: disposable, high efficiency, to ASHRAE 52.2.
 - 2.6.2 Holding frame: galvanized steel with bracing.
 - 2.6.3 Media support: welded wire grid.
 - 2.6.4 Performance: average atmospheric dust spot efficiency 95 % to ASHRAE 52.2.
 - 2.6.5 Fire rated: to ULC -S111.
- 2.7 HEPA ABSOLUTE PACKAGE FILTERS 99.97 % EFFICIENCY
 - 2.7.1 Media: water resistant fibrous glass.
 - 2.7.2 Holding frame: cadmium plated steel or 316 stainless steel.by unit manufacturer.
 - 2.7.3 Housing and sealing system: manufacturers' standard, suitable for pressure application.
 - 2.7.4 Efficiency: minimum 99.97 % overall on hot DOP test, using 0.003 mm particles.
- 2.8 ROLL TYPE FILTERS
 - 2.8.1 Media: adhesive coated fibrous glass: to CAN/CGSB -115.13.
 - 2.8.2 Holding frame and media support: minimum 2.0 mm thick galvanized steel.
 - 2.8.2.1 Media enclosure: to contain clean roll of 20 m length of media completely enclosed in sheet metal housing or cover.
 - 2.8.3 Drive mechanism: electric gear reducer motor to wind spool through chain and sprocket assembly. Provide automatic device to prevent reverse rotation of used media roll, and to maintain tension on media in active air stream.
 - 2.8.4 Controls: prewired package to advance media when filter resistance exceeds preselected high limit. Media runout switch to stop travel and indicate runout. Hand-off-auto switch to override controls and advance media.

- 2.8.5 Performance: average atmospheric dust spot efficiency 80% to ASHRAE 52.1.
- 2.9 ELECTRONIC AIR CLEANERS
 - 2.9.1 Electronic agglomerator: independently supported and nested collection cells including ionizing wires, grounded struts, positive and negative plates, insulators, ionizer and plate contacts. Insulators: locate out of air stream.
 - 2.9.2 Power pack:
 - 2.9.2.1 Self-contained, prewired rectifying unit for approximately 12,000V DC for ionizer and 6,000V DC for precipitator.
 - 2.9.2.2 Overload protection, on-off switch, pilot light indicating operating status and safety accessories.
 - 2.9.3 Control package to be complete with: airflow switch, manual reset, safety switches, warning lights, high voltage warning signs and signal lights.
 - 2.9.4 Efficiency electronic: 98% to ASHRAE 52.1.
- 2.10 ACTIVATED CARBON TYPE FILTERS
 - 2.10.1 Media:
 - 2.10.1.1 Regenerative activated carbon from coconut shell: to AHSRAE 145.1 and 145.2.
 - 2.10.1.2 Absorption capacity, 50-55 minute, in accordance with standard accelerated chloropicrin test.
 - 2.10.1.3 Density: 550 kg/m³.
 - 2.10.1.4 95 hardness in accordance with Ball abrasion test.
 - 2.10.1.5 Particle size (Tyler mesh screen): 6.3 x 10 mm.
 - 2.10.1.6 Quantity of media: 4.25 kg/100 L/s.
 - 2.10.2 Holding frame: removable, non-disposable, corrosion resistant steel.
 - 2.10.3 Filter housing: corrosion resistant steel.
 - 2.10.4 Test element:
 - 2.10.4.1 Detachable, to indicate extent of saturation of actual installation.
 - 2.10.4.2 1 per bank.
- 2.11 FILTER GAUGES - DIAL TYPE
 - 2.11.1 Housing: Die cast aluminum case and bezel, with acrylic cover. Exterior finish coated to withstand 168 hour salt spray corrosion test. Diaphragm actuated, direct reading.
 - 2.11.2 Accuracy: + 2% of full scale (+ 3% on 0-125 PA, and + 4% on -0-60PA.), throughout range at 21.1°C.
 - 2.11.3 Pressure Limits: 500 mm Hg to 100 kPa.
 - 2.11.4 Overpressure: Relief plug opens at approximately (1.72 kPa), standard.
 - 2.11.5 Temperature Limits: 6.67 to 60°C.
 - 2.11.6 Size: 101.6 mm diameter dial face.
 - 2.11.7 Mounting Orientation. Diaphragm in vertical position.
 - 2.11.8 Process Connections: 2- 1/8 female NPT duplicate high and low pressure taps one pair side and one pair back.
 - 2.11.9 Standard Accessories: Two 1/8 NPT plugs for duplicate pressure taps, two 1/8 NPT pipe thread to rubber tubing adapters and three flush mounting adapters with screws.
 - 2.11.10 Range: 0-250 Pa.

3. PART3 EXECUTION**3.1 MANUFACTURER'S INSTRUCTIONS**

- 3.1.1 Compliance: comply with manufacturer's written recommendations or specifications, including product technical bulletins, handling, storage and installation instructions, and datasheet.

3.2 INSTALLATION GENERAL

- 3.2.1 Install in accordance with manufacturer's recommendations and with adequate space for access, maintenance and replacement.

3.3 ACTIVATED CARBON TYPE FILTERS

- 3.3.1 During testing, adjusting and balancing, install substitute media.
- 3.3.2 Install permanent media only after all painting is completed.

3.4 REPLACEMENT MEDIA

- 3.4.1 Replace all media with new upon acceptance.
- 3.4.2 Filter media to be new and clean, as indicated by pressure gauge, at time of acceptance.

3.5 HEPA FILTERS

- 3.5.1 Use components and devices recommended by manufacturer to ensure complete integrity and to ensure easy removal and replacement, even when dressed in anti-contamination clothing.
- 3.5.2 Provide proper permanent facilities for challenging integrity with aerosol injector downstream of pre-filters and test sampling manifold downstream of HEPA filter. Location of injector and sampling manifold to be approved by manufacturer.
- 3.5.3 During TAB, install substitute media having similar pressure drop.
- 3.5.4 Before acceptance, perform tests to demonstrate integrity of complete installation.

3.6 FILTER GAUGES

- 3.6.1 Install type as indicated across each filter bank (pre-filter, high efficiency filter and final filter) in approved and easy readable location.
- 3.6.2 Mark each filter gauge with value of pressure drop for clean condition and manufacturer's recommended replacement (dirty) value.

3.7 CLEANING

- 3.7.1 Proceed in accordance with Section 01 74 00 - Cleaning.
- 3.7.2 Upon completion and verification of performance of installation, remove surplus materials, excess materials, rubbish, tools and equipment.

END OF SECTION

SECTION 234001:**AIR FILTERS****PART 1 - GENERAL****PART 1 RELATED DOCUMENTS**

1. Drawings and general provisions of Contract, including General and Special Conditions and Division-1 Specification Sections, apply to work of this Section.
2. The requirements specified in this section apply to all related sections in this Division. The requirements of all related sections, elsewhere in this division also apply to this section unless specified to the contrary.

PART 2 DESCRIPTION OF WORK

1. The work includes the providing of all labor, supervision, materials, equipment, accessories, services and tests necessary to complete, make ready, and set to work for acceptance by the Owner, all filters work in accordance with Drawings and Specifications.

1.3 QUALITY ASSURANCE

1. Manufacturers: Firms regularly engaged in manufacture of filters of the types, materials and sizes required, whose products have been in satisfactory use in similar service for not less than 5 years, as approved by Engineer.
2. Standards Compliance: Comply with requirements of applicable local codes and the standards.

1.4 SUBMITTALS

1. Shop drawings indicating type, size and location of air filters, details of holding frames, installation requirements, efficiency, initial and final pressure drops, and gross media area.
2. Product Data: Manufacturer's data sheets, plus independent testing lab certification of efficiency, pressure drop, and dust holding capacity.
3. Samples, when requested.

PART 2-PRODUCTS**2.1 PRE - FILTERS**

1. Air filters shall be medium efficiency, flat, disposable type, minimum of 10 mm thick.
2. Each air filter shall consist of a permanent corrosion resistant holding frame and a replaceable factory-assembled filter element incorporating a fine-fibered synthetic medium. The permanent holding frame shall be supplied with a suitable gasket and retaining clips to maintain a positive pressure seal between the frame and the replaceable filter element. The holding frame shall be provided with matching rivet holes and a peripheral gasket to facilitate installation and prevent leakage between the frames.
3. The average efficiency of the filter shall not be less than 85% by arrestance .
4. Filter assemblies and media shall comply with NFPA, local codes and any local Fire Department requirements.
5. Filter media shall be essentially non-combustible and shall not produce toxic vapors if burned.
6. During construction, provide 10 mm deep filters in any system in operation. After construction, and prior to issuance of work all filters are to be replaced with new.

2.2 AIR FILTERS (HIGH EFFICIENCY DRY 'V' SHAPED BAG TYPE) FOR A.H.U.

1. Air filters shall be high efficiency dry 'V' shaped bag type, as scheduled.

2. Each air filter shall consist of a permanent corrosion resistant holding frame and a replaceable factory-assembled filter element incorporating a fine-fibred all-glass medium. The permanent holding frame shall be supplied with a suitable gasket and retaining clips to maintain a positive pressure seal between the frame and the replaceable filter element. The holding frame shall be provided with matching rivet holes and a peripheral gasket to facilitate installation and prevent leakage between the frames. Provide not less than 5 M of media area per 1700 M /HR.
3. The initial resistance shall not exceed pressure drop scheduled at 2.5 m/sec. The average efficiency of the filter shall not be less than 85% using atmospheric dust, per ASHRAE Test Standard 52-76.
4. The complete filter including frame shall not exceed 925 mm in depth. Filters installed in side access housings shall not exceed 1100 mm in depth.
5. Where indicated, the bank of filters shall be erected so that the filter elements can be installed and removed from the side of the filter bank.
6. Filter assemblies and media shall comply with local codes
7. Provide and install a differential Gage, on each filter bank of proper scale.
8. Units shall be installed complete with pressure fittings for duct and flexible double column plastic tubing. The range of pressure scale shall be from 0 to 50 mm.
9. Where used in conjunction with package unit, provide factory fabricated 1.8 mm steel, full housing with access doors on both sides of the housing, and integral pre-filter section.
10. On built-up banks which are more than 4 frames high and 4 frames wide, provide a 75 mm wide by 1.8 mm or heavier, steel stiffener strap vertically every two frames in width.

2.3 BAG-IN/BAG-OUT FILTER SYSTEM FOR LABORATORY EXHAUST

1. System filter elements in direction of air flow shall consist of a 50mm deep 30% ASHRAE efficiency pre-filter, 290mm deep nuclear-grade HEPA filter, housing in direction of flow shall contain the pre-filter and HEPA filter.
2. Housings shall be fabricated from 14 ga. type 304 stainless steel, and shall be designed for positive or negative pressures of 10" w.g. All internal parts shall be type 304 stainless steel. Housings shall be of 100% welded construction.
3. Housings shall be equipped with two separate locking lever mechanisms of 304 stainless steel, with a cam-actuated spring-loaded face bar to maintain gasket compression. Levers must be in their closed and locked position before access door can be installed.
4. One oval access opening shall be provided for each filter housing to accommodate installation and removal of filter and/or pre-filter into an 8 MIL PVC casing. two "O" ring grooves shall be provided in the oval bagging flange. Bags shall be completely contained within the housing after attachment of the opening cover.
5. Bags shall be of 8 MIL PVC constructions with integral 6mm dia. elastic compression band at the open end. Bags shall have three glove sleeves to simplify filter manipulation.
6. Removable access door shall be welded pan construction with ample bag storage space plus two convenient handles to facilitate removal. Door shall be equipped with four captive knob fasteners for sealing the door without special tools. Access door shall have a turned-in gasketed flange which shall seal directly against the housing.
7. All factory welders and welding procedures shall be qualified in accordance with ASME Boiler and Pressure Code, Section IX.
8. Housings shall comply with USNRC requirements, and shall be pressure leak- tested in accordance with ANSI N509 and ANSI N510.
9. Housings shall be equipped with two plugged 35mm half coupling test ports.
10. 50mm turned-in connecting flanges shall be provided on air entering and air leaving sides of the housing.

11. Pre-filters shall be 50mm extended surface type, 25-30% efficiency per ASHRAE Standard 52-76.
12. HEPA filters shall be nuclear meeting construction and testing requirements of MIL-F-51068. Media shall be waterproof, fire retardant, and radiation-resistant. Filters shall be furnished with aluminum separators, and 14 ga. cadmium plated steel cell sides. Filters shall bear UL-586 labels, and shall have a D.O.P. efficiency of 99.97%.
13. Each housing shall be furnished with a Dwyer Series 3000 Photohelic gage.
14. Unit to be provided with lifting lugs for ease of installation.
15. Unit to be provided with absorber test canisters for monitoring of the status of the absorbent in the absorber filter.
16. Bag-in/Bag-out housings, pre-filters, HEPA filters, and carbon absorbers shall be as manufactured by American Air Filter Company, Farr Co. or Cambridge.

PART 3 - EXECUTION

3.1 INSPECTION

1. Examine area and condition under which filter units are to be installed. Notify (Engineer) in writing of conditions detrimental to proper completion of the work. Do not proceed with the work until satisfactory conditions have been corrected.

3.2 INSTALLATION

1. Install air filters in accordance with approved drawings and manufacturer's recommendations.
2. Filters shall generally be housed in factory fabricated medium capacity filter sections ("V" bank arrangement) of air handling units as provided under Section 15855 unless otherwise specified or noted on the drawings.

3.3 CONSTRUCTION FILTERS

1. Provide two complete spare sets of filters for each air system as specified to serve during construction and, testing and balancing periods.
 1. One set installed before systems are turned on.
 2. One set installed for each air system is ready for testing and balancing as specified under Section 15990.
2. Install one complete set of filters for all air system as specified upon final acceptance of each air system.

3.4 PACKING

All filters shall be kept in domestic packing until start up

END OF SECTION

PART 1- GENERAL**1.1 RELATED DOCUMENTS**

1. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division-1 Specification Sections, apply to work of this Section.
2. General Provisions for HVAC Work, Section 15020, applies to work of this Section.
3. The requirements of this Section apply to equipment specified elsewhere in the specification.

1.2 DESCRIPTION OF WORK

1. The work includes the providing of all labor, supervision, materials, equipment, accessories, services and tests necessary to complete and make ready for operation by the Owner.

1.3 QUALITY ASSURANCE

1. Manufacturers: Firms regularly engaged in manufacture of radiators, units and cabinet heaters of the types, materials and sizes required, whose products have been in satisfactory use in similar service for not less than 5 years. Provide equipment produced by a manufacturer listed as an Acceptable Manufacturer in this section. Furnish all equipment from one manufacturer.
2. Standards Compliance: Comply with requirements of applicable local codes and the following:
 1. Egyptian codes.
 2. Guarantee each unit to operate at the certified sound levels. Replace any unit which does not fulfill this requirement.
3. Warranty: Minimum 5-year for compressors.

1.4 SUBMITTALS

1. Product Data: Submit manufacturer's product data, including printed technical literature, and catalog cuts for each type of Fan Coil Unit and Condensing Unit, indicating connection details, dimensions and required clearances, and installation instructions.
2. Schedule: Submit a schedule showing manufacturer, models, sizes, and capacities for approval before ordering the equipment.

PART 2 - PRODUCTS**2.1 DX- FAN COIL UNITS**

Unit shall be self-contained, packaged, factory assembled and prewired, consisting of cabinet and frame, supply fan, electric heating elements (Heat pump - reversed cycle is approved option), controls, air filters and refrigerant cooling coil as follows:

1. Cabinet: Galvanized steel with baked enamel finishes, access doors or removable access panels with quick fasteners [screwdriver operated flush cam type.] locking door handle type with piano hinges.] Structural members shall be minimum 18 gage (1.20 mm), with access doors or removable panels of minimum 20 gage (0.90 mm).
2. Insulation: 50 mm thick neoprene coated glass fiber on surfaces where conditioned air is handled. Protect edges from erosion.
3. Supply Fan: Forward curved centrifugal type, resiliently mounted with V-belt drive, adjustable variable pitch motor pulley, and rubber isolated hinge mounted motor.
4. Air Filters: 50 mm thick glass fiber disposable media in metal frames.
5. EVAPORATING COIL
 1. Provide copper tube aluminum fin coil assembly with galvanized drain pan and connection.

SECTION 234002:**INDIVIDUAL AIR CONDITIONING UNITS**

1. Provide thermostatic expansion valves for units.

1.2 AIR COOLED CONDENSING UNIT

Units of draw-through design complete with fans, motors, drain pan, auxiliary drain pan and condensing coil and compressor, as follows:

1 CONDENSING COIL

1. Provide copper tube aluminum fin coil assembly with sub cooling rows.
2. Provide thermostat to cycle condenser fans.

2 COMPRESSOR

1. Provide hermetic compressor, resiliently mounted with positive lubrication, crankcase heater, high and low pressure safety controls, motor overload protection, suction and discharge service valves and gage ports, and filter drier.
2. Five minute timed off circuit shall delay compressor start.
3. Outdoor thermostat shall energize compressor above 14 ° C ambient.
4. Provide step capacity control cycling compressors.
- 5 Condensate Drain pan: Drain pan to direct condensate to condenser coil for reevaporation.
- 6 Condenser Fan: Provide direct drive propeller fans, resiliently mounted with fan guard, motor overload protection, wired to operate with compressor.

1.3 OPERATING CONTROLS

1. Provide low voltage, adjustable thermostat to control heater stages in sequence with delay between stages, compressor and condenser fan.
2. Include system selector switch off-heat-auto-cool and fan control switch (auto-on).
3. Provide double acting thermostat with minimum two stage heating and 2 stages cooling.
4. Locate thermostat in return air.

PART 3 - EXECUTION**3.1 INSPECTION**

1. Examine area and condition under which fan coil units are to be installed. Notify Project Director in writing of conditions detrimental to proper completion of the work. Do not proceed with the work until unsatisfactory conditions have been corrected.
2. Verify that proper power supply is available.

3.2 INSTALLATION

1. Furnish and install factory assembled fan coil units and condensing units of the types, sizes, capacities, and arrangements indicated on the drawings and specified herein.
2. Install in accordance with manufacturer's instructions.
3. Coordinate installation of units with architectural and electrical work.
4. Supply units fully charged with refrigerant and filled with oil.
5. Scheduled performance is based on ARI 210 test conditions. Scheduled sound rating is based on ARI 270.

END OF SECTION

SECTION 237400:**PACKAGED OUTDOOR HVAC EQUIPMENT****1. PART1 GENERAL****1.1 SUMMARY**

- 1.1.1 Materials and installation for self-contained multizone and single zone, gas, electric, hot water and refrigeration packaged rooftop HVAC units.

1.2 RELATED SECTIONS

- 1.2.1 Section 01 33 00 – Submittal Procedures.
- 1.2.2 Section 01 45 00 – Quality Control
- 1.2.3 Section 01 74 21 – Construction/Demolition Waste Management and Disposal
- 1.2.4 Section 01 78 00 – Closeout Submittals.
- 1.2.5 Section 01 91 13.13 – Commissioning (Cx) Requirements.
- 1.2.6 Section 23 08 02 – Cleaning and Startup of Mechanical Piping Systems

1.3 REFERENCES

- 1.3.1 American National Standards Institute (ANSI)/Air Conditioning and Refrigeration Institute (ARI)
 - 1.3.1.1 ANSI/ARI 210/240, Unitary Air-Conditioning and Air-Source Heat Pump Equipment.
 - 1.3.1.2 ARI 270, Sound Rating of Outdoor Unitary Equipment.
- 1.3.2 ANSI/UL 1995 B, Standard for Heating and Cooling Equipment.
- 1.3.3 Canadian Standards Association (CSA)
 - 1.3.3.1 CSA B52, Mechanical Refrigeration Code.
 - 1.3.3.2 CSA C22.1, Canadian Electrical Code.
- 1.3.4 National Roofing Contractors Association (NRCA)
- 1.3.5 National Fire Protection Association (NFPA)
 - 1.3.5.1 NFPA 90A, Installation of Air Conditioning and Ventilating Systems.
- 1.3.6 American Bearing Manufacturer's Association (ABMA)
 - 1.3.6.1 ANSI/ABMA 9 Load Ratings and Fatigue Life for Ball Bearings
 - 1.3.6.2 ANSI/ABMA 11 Load Ratings and Fatigue Life for Roller Bearings.
- 1.3.7 Air Movement and Control Association (AMCA)
 - 1.3.7.1 AMCA 300 Reverberant Room Method for Sound Testing of Fans.
- 1.3.8 National Electrical Manufacturer's Association (NEMA)
 - 1.3.8.1 NEMA MG1 Motors and Generators
 - 1.3.8.2 NEMA ICS 7-1 Safety Standards for Construction and Guide for Selection, Installation and Operation of Adjustable Speed Drive Systems.
- 1.3.9 Provincial Boiler, Pressure Vessel and Compressed Gas Regulations.

1.4 SUBMITTALS

- 1.4.1 Submittals in accordance with Section 01 33 00 - Submittal Procedures.
- 1.4.2 Product Data:
 - 1.4.2.1 Submit manufacturer's printed product literature, specifications and datasheet for packaged rooftop HVAC units.
- 1.4.3 Submit WHMIS SDS in accordance with Section 01 33 00 - Submittal Procedures. Indicate VOC's for adhesive and solvents during application and curing.
- 1.4.4 Shop Drawings:
 - 1.4.4.1 Submit shop drawings to indicate project layout and dimensions; indicate:

- 1.4.4.1.1 Equipment, piping, and connections, together with valves, strainers, control assemblies, thermostatic controls, auxiliaries and hardware, and recommended ancillaries which are mounted, wired and piped ready for final connection to building system, its size and recommended bypass connections.
- 1.4.4.1.2 Piping, valves, fittings shipped loose showing final location in assembly.
- 1.4.4.1.3 Control equipment shipped loose, showing final location in assembly.
- 1.4.4.1.4 Complete internal panel pneumatic tube piping and wiring and external panel pneumatic tube piping and wiring, both as schematics and as actually assembled.
- 1.4.4.1.5 Dimensions, internal and external construction details, recommended method of installation with proposed structural steel support, mounting curb details, sizes and location of mounting bolt holes; include mass distribution drawings showing point loads.
- 1.4.4.1.6 Detailed composite wiring diagrams for control systems showing factory installed wiring and equipment on packaged equipment or required for controlling devices of ancillaries, accessories, controllers.
- 1.4.4.1.7 Pump and fan performance curves.
- 1.4.4.1.8 Details of vibration isolation.
- 1.4.4.1.9 Estimate of sound levels to be expected across individual octave bands in dB referred to A rating.
- 1.4.4.1.10 Type of refrigerant used.
- 1.4.5 Test Reports: submit certified test reports from approved independent testing laboratories indicating compliance with specifications for specified performance characteristics and physical properties.
- 1.4.6 Certificates: submit certificates signed by manufacturer certifying that materials comply with specified performance characteristics and physical properties.
- 1.4.7 Instructions: submit manufacturer's installation instructions.
- 1.4.8 Manufacturer's Field Reports: manufacturer's field reports specified.
- 1.4.9 Closeout submittals: submit maintenance and engineering data for incorporation into manual specified in Section 01 78 00 - Closeout Submittals include data as follows:
 - 1.4.9.1 Indicate: brief description of unit, indexed, with details of function, operation, control, and service for components.
 - 1.4.9.2 Provide for units, manufacturer's name, type, year, number of units, and capacity.
- 1.5 QUALITY ASSURANCE
 - 1.5.1 Pre-Installation Meetings:
 - 1.5.1.1 Convene pre-installation meeting one week prior to beginning work of this Section and on-site installations.
 - 1.5.1.1.1 Verify project requirements.
 - 1.5.1.1.2 Review installation and substrate conditions.
 - 1.5.1.1.3 Co-ordination with other building subtrades.
 - 1.5.1.1.4 Review manufacturer's installation instructions and warranty requirements.

1.6 DELIVERY, STORAGE AND HANDLING**1.6.1 Waste Management and Disposal:**

- 1.6.1.1 Separate waste materials for reuse and recycling in accordance with Section 01 74 21 - Construction/Demolition Waste Management and Disposal.
- 1.6.1.2 Remove from site and dispose of packaging materials at appropriate recycling facilities.
- 1.6.1.3 Collect and separate for disposal, paper, plastic, polystyrene, corrugated cardboard, packaging material in appropriate on-site bins for recycling in accordance with Waste Management Plan (WMP).
- 1.6.1.4 Separate for reuse and recycling and place in designated containers steel, metal, plastic waste in accordance with Waste Management Plan (WMP).
- 1.6.1.5 Handle and dispose of hazardous materials in accordance with Canadian Environmental Protection Act (CEPA), Transportation of Dangerous Goods Act (TDGA), Regional and Municipal, regulations.
- 1.6.1.6 Divert unused metal materials from landfill to metal recycling facility as approved by Owner.

1.7 WARRANTY

- 1.7.1 Contractor hereby warrants that packaged rooftop HAVC units and refrigeration compressors will function and operate in accordance with GC 31.1, but for 24 months.

2. PART2 PRODUCTS**2.1 GENERAL**

- 2.1.1 Roof mounted, self-contained single zone unit with electric heating elements or hot water coil and DX refrigeration and bear label of CSA.
- 2.1.2 Units to consist of cabinet and frame, supply fan, control, air filter, refrigerant cooling coil, compressor, condenser coil and fans, motorized outside air damper, return damper, motorized exhaust damper.
- 2.1.3 Prefabricated roof curb to conform to requirements of National Roofing Contractors Association (NRCA), minimum height 450 mm.
- 2.1.4 Conform to ANSI/ARI 210/240, rating for unit larger than 40 kW nominal.

2.2 CABINET

- 2.2.1 Cabinets: weatherproofing tested and soundproofing tested to ARI 270, dbA at 3 m free field.
- 2.2.2 Framing and supports: 2 mm thick welded steel, galvanized after manufacture, with lifting lugs at top of unit and/or fork lift slots at bottom.
- 2.2.3 Outer casing: weathertight galvanized steel with baked enamel finish, to Section 09 91 13 - Exterior Painting.
- 2.2.4 Access: removable gasketted hinged doors or panels with locking door handle type or screwdriver operated flush cam type fasteners.
- 2.2.5 Insulation: neoprene coated glass fiber on surfaces, 50 mm thick, 32 kg/m³ density.

2.3 FANS

- 2.3.1 Centrifugal, forward curved impellers, backward inclined, or airfoil, statically and dynamically balanced. Multi V-belt drive with adjustable variable pitch motor pulley, rubber spring isolated hinge mounted

motor fan, and motor integrally mounted on isolation base, separated from unit casing with flexible connections and spring isolators. Vibration isolators: 95% efficiency.

2.4 AIR FILTERS

2.4.1 50 mm thick, 30 % efficiency, metal framed, replaceable media or throwaway.

2.4.2 To meet NFPA 90A, air filter requirements type Class 1 or type Class 2.

2.5 ELECTRIC HEATERS

2.5.1 Nickel chromium electric resistant type, 64.6 kW/m² – stage maximum density at 2.5 m/s.

2.5.2 Controls:

2.5.2.1 Panel board with multi- stage or modulating SCR controller.

2.5.2.2 Indicating light centre.

2.5.2.3 Remote thermostats as indicated.

2.5.2.4 Fuseblocks (one per step unless otherwise specified).

2.5.2.5 Built-in control transformer.

2.5.2.6 Thermal cut outs: manual reset disc types, one per circuit, one linear bulb type automatic reset.

2.5.2.7 Built-in un-fused disconnect switch.

2.5.2.8 Elements control: accessible with protection against no air flow, short and grounds, and of self checking type.

2.5.2.9 High limit temperature control: de-energize heating elements to protect against over heating.

2.5.2.10 Supply fan: start before electric elements are energized and continue operating until temperature reaches minimum setting. Include switch for continuous fan operation.

2.5.2.11 Conform to Canadian Electrical Code CSA C22.1.

2.6 HOT WATER COIL

2.6.1 Aluminum fins, mechanically bonded to copper tubes.

2.6.2 Piping: complete with shut off valves, drain valves, unions or flanges.

2.6.3 Hydrostatically tested to 1.7 MPa.

2.7 REFRIGERATION

2.7.1 Conform to CSA B52 and ANSI/UL 465 requirements.

2.7.2 Compressor/condenser section:

2.7.2.1 Semi-hermetic or hermetic compressors, vibration isolated with flexible suction and discharge connections, oil sight glass, oil pressure switch, crankcase heater, and automatic pump down system with control to liquid line solenoid valve.

2.7.2.2 Fans: propeller type with single piece spun venturi outlets and zinc plated guards. Motors shall be sequenced for head pressure control.

2.7.2.3 Electrical system shall have operating controls, oil and refrigerant pressure protection, motor overload protection, weatherproof electrical wiring with weatherproof, rain tight disconnect.

2.7.2.4 Include refrigerant piping with, sight glass, filter drier and valves.

2.7.2.5 Condenser: staggered copper tube, aluminum fin coil assembly with sub-cooling rows to provide 6 °C sub-cooling.

2.7.2.6 Capacity reduction: cylinder unloading. Provide flooding for head pressure control for low ambient operation down to 0 °C ambient temperature.

2.7.2.7 Refrigerant: R 134a.

2.7.3 Evaporator:

- 2.7.3.1 Rated to ANSI/ARI 210/240.
- 2.7.3.2 Thermostatic expansion valve, with adjustable super heat and external equalizer.
- 2.7.3.3 Coil: NPS 1/2 or NPS 5/8 od staggered seamless copper tubes expanded into aluminum fins and insulated condensation pan.
- 2.7.3.4 Cooling coil condensate drain pans: designed to avoid standing water, to be easily cleaned or removable for cleaning. Drain connection to have deep seal trap and be complete with trap seal primer.

2.8 CONTROLS

- 2.8.1 In addition to safety controls, provide smoke sensors in return to NFPA standards, low limit on supply and freeze protection on water coils.
- 2.8.2 Single zone cooling control:
 - 2.8.2.1 Zone sensor or room thermostat to activate cooling relay in control circuit cycling compressor. Provide safeties and pressure controls. Condenser fans to operate in sequence.
 - 2.8.2.2 When call for cooling is satisfied, relay is de-energized closing liquid line solenoid valve and pumps down. On two compressor units provide separate circuits to evaporator and condenser.
- 2.8.3 Mixed air single zone unit:
 - 2.8.3.1 Motorized outside, return and automatic power exhaust or gravity, relief dampers with spring return damper operator and control package to automatically vary outside air quantity. Outside air and exhaust air dampers, normally closed.
 - 2.8.3.2 Tight fitting opposed blade dampers with neoprene or suitable gaskets, bronze or synthetic bushings and 1% maximum leakage.
 - 2.8.3.3 Damper operation: 24V, spring return motor with gear train sealed in oil, and heater for operation under minus 18°C.
 - 2.8.3.4 Mixed air controls: maintain 13 °C mixed air temperature, lock out compressor below 14°C ambient, restart 17°C.
- 2.8.4 Single Zone Heat-Cool Unit
 - 2.8.4.1 Low voltage, adjustable room thermostat controls, heater stages in sequence with delay between stages, compressor and supply fan shall maintain room temperature setting.
 - 2.8.4.2 Thermostat: include system selector switch day-night, heat-cool-auto-off and fan control switch (on-auto).
 - 2.8.4.3 Mixed air controls: maintain 13 °C mixed air temperature, lock out compressor below 14°C ambient, restart 17°C.
- 2.8.5 Night mode: unit cycles as unit heater with 100% recirculation on winter cycles.
- 2.8.6 Night set-back: 15 ° C.

2.9 REMOTE PANEL

- 2.9.1 Provide remote readout panel for each unit containing:
 - 2.9.1.1 Signal lights indicating system status, heating system failure cooling system failure and dirty filters.
 - 2.9.1.2 Check switches proving signal light operation.
 - 2.9.1.3 System on-off switch.
 - 2.9.1.4 Fan on-off switch.
 - 2.9.1.5 Manual 6 h timer to override night-set back control.

- 2.9.2 Provide gauges in remote panel indicating outside air, mixed air, return air and discharge air temperatures for each deck before heat exchangers.
- 2.10 CAPACITY
 - 2.10.1 Capacity: see schedule.
- 3. PART3 EXECUTION
 - 3.1 MANUFACTURER'S INSTRUCTIONS
 - 3.1.1 Compliance: comply with manufacturer's written recommendations or specifications, including product technical bulletins, handling, storage and installation instructions, and datasheet.
 - 3.2 INSTALLATION
 - 3.2.1 Install as per manufacturers' instructions on roof curbs provided by manufacturer.
 - 3.2.2 Manufacturer's representative to certify installation, supervise start-up and commission unit.
 - 3.2.3 Run drain line from cooling coil condensate drain pan to discharge over roof.
 - 3.3 FIELD QUALITY CONTROL
 - 3.3.1 Manufacturer's Field Services:
 - 3.3.1.1 Have manufacturer's representative of products supplied under this Section review work involved in handling, installation/application, protection and cleaning of its products, and submit written reports, in acceptable format, to verify compliance of work with Contract.
 - 3.3.1.2 Provide manufacturer's field services, consisting of product use recommendations and periodic site visits for inspection of product installation, in accordance with manufacturer's instructions.
 - 3.3.1.3 Schedule site visits to review work at stages listed:
 - 3.3.1.3.1 After delivery and storage of products, and when preparatory work on which work of this Section depends is complete, but before installation begins.
 - 3.3.1.3.2 Twice during progress of work at 25% and 60% complete.
 - 3.3.1.3.3 Upon completion of work, after cleaning is carried out.
 - 3.3.2 Obtain reports within three (3) working days of review and submit immediately to Owner.
 - 3.3.3 Verify accessibility, serviceability of components including motorized dampers, filters coils, fans, motors, operators, humidifiers, sensors, electrical disconnects.
 - 3.3.4 Verify accessibility, cleanability, drainage of drain pans for coils, humidifiers.
 - 3.3.5 Performance Verification:
 - 3.3.5.1 General:
 - 3.3.5.1.1 In accordance with Section 23 08 02 - Cleaning and Start-up of Mechanical Piping Systems, supplemented as specified herein.
 - 3.3.5.2 Rooftop Air Handling Units:
 - 3.3.5.2.1 Set zone mixing dampers for full cooling, except that where diversity factor forms part of design set that % of zone dampers to full heating.

- 3.3.5.2.2 Set outside air and return air dampers for minimum outside air.
- 3.3.5.2.3 Set face and bypass dampers so face dampers are fully open and bypass dampers are fully closed.
- 3.3.5.2.4 Check for smooth, vibration less correct rotation of supply fan impeller.
- 3.3.5.2.5 Measure supply fan capacity.
- 3.3.5.2.6 Adjust impeller speed as necessary and repeat measurement of fan capacity.
- 3.3.5.2.7 Measure pressure drop for each component of air handling unit.
- 3.3.5.2.8 Set outside air and return air dampers for the % of outside air required by design and repeat measurements of fan capacity.
- 3.3.5.2.9 Reduce differences between fan capacity at minimum and maximum outside air less than 5 %.
- 3.3.5.2.10 Set face and bypass dampers to full bypass and repeat measurement of fan capacity.
- 3.3.5.2.11 Reduce difference between fan capacity with F&BPD fully closed to bypass and fully open to bypass to less than 5 %.
- 3.3.5.2.12 Reduce difference between fan capacity at full cooling and fan capacity at full heating to less than 5 %.
- 3.3.5.2.13 OAD: verify for proper stroking, interlock with RAD.
- 3.3.5.2.14 Measure DBT, WBT of SA, RA, EA.
- 3.3.5.2.15 Measure air cooled condenser discharge DBT.
- 3.3.5.2.16 Measure flow rates (minimum and maximum) of SA, RA, EA, relief air.
- 3.3.5.2.17 Simulate maximum cooling load and measure refrigerant hot gas and suction temperatures and pressures.
- 3.3.5.2.18 Use smoke test to verify no short-circuiting of EA, relief air to outside air intake or to condenser intake.
- 3.3.5.2.19 Simulate maximum heating load and:
 - 3.3.5.2.19.1 Verify temperature rise across heat exchanger.
 - 3.3.5.2.19.2 Perform flue gas analysis. Adjust for peak efficiency.
 - 3.3.5.2.19.3 Verify combustion air flow to heat exchanger.
 - 3.3.5.2.19.4 Simulate minimum heating load and repeat measurements.
- 3.3.5.2.20 Measure radiated and discharge sound power levels under maximum heating demand and under maximum cooling demand with compressors running.
- 3.3.5.2.21 Verify operating control strategies, including:
 - 3.3.5.2.21.1 Heat exchanger operating and high limit.
 - 3.3.5.2.21.2 Early morning warm-up cycle.
 - 3.3.5.2.21.3 Freeze protection.
 - 3.3.5.2.21.4 Economizer cycle operation, temperature of change-over.

- 3.3.5.2.21.5 Alarms.
- 3.3.5.2.21.6 Voltage drop across thermostat wiring.
- 3.3.5.2.21.7 Operation of remote panel including pilot lights, failure modes.
- 3.3.5.2.22 Set zone mixing dampers for full heating and repeat measurements.
- 3.3.5.2.23 Measure leakage past zone mixing dampers by taking temperature measurements. Reduce leakage to less than 5 %.
- 3.3.5.2.24 Measure return fan capacity.
- 3.3.5.2.25 Adjust impeller speed as necessary and repeat measurement of return fan capacity.
- 3.3.5.2.26 Check capacity of heating unit.
- 3.3.5.2.27 Measure DX refrigeration system performance as specified Section.
- 3.3.5.2.28 Refer to other sections of these specifications for PV procedures for other components.
- 3.3.5.3 Start-Up:
 - 3.3.5.3.1 General: in accordance with Section 23 08 02 - Cleaning and Start-up of Mechanical Piping Systems.
- 3.3.5.4 Verify accessibility, serviceability of components including motorized dampers, filters, coils, fans, motors, operators, humidifiers, sensors, electrical disconnects.
- 3.3.5.5 Verify accessibility, clean ability, drainage of drain pans for coils, humidifiers.
- 3.3.6 Commissioning Reports:
 - 3.3.6.1 In accordance with Section 01 91 13.13 - Commissioning (Cx) Requirements: reports supplemented as specified herein. Include:
 - 3.3.6.1.1 Report forms as specified Section 01 91 13.13 - Commissioning (Cx) Requirements: Report Forms and Schematics.
- 3.4 DEMONSTRATION
 - 3.4.1 Training: in accordance with Section 01 91 13.13 - Commissioning (Cx) Requirements: Training of O&M Personnel, supplemented as specified.
- 3.5 CLEANING
 - 3.5.1 Perform cleaning operations as specified in Section 01 74 00 - Cleaning and in accordance with manufacturer's recommendations.
 - 3.5.2 On completion and verification of performance of installation, remove surplus materials, excess materials, rubbish, tools and equipment.

END OF SECTION

SECTION 23730016:

AIR HANDLING UNITS-PACKAGED

1 PART1 GENERAL

1.4 RELATED SECTIONS

- 1.4.2 Section 01 33 00 – Submittal Procedures.
- 1.4.3 Section 01 74 21 – Construction/Demolition Waste Management and Disposal.
- 1.4.4 Section 01 78 00 – Closeout Submittals.
- 1.4.5 Section 23 05 48 – Vibration and Seismic Controls for HVAC Piping and Equipment.
- 1.4.6 Section 23 33 00 – Air Duct Accessories.
- 1.4.7 Section 23 33 15 – Dampers - Operating.
- 1.4.8 Section 23 40 00 – HVAC Air Cleaning Devices.
- 1.4.9 Section 23 72 00 – Air-to-Air Energy Recovery Equipment.
- 1.4.10 Section 23 84 13 – Humidifiers.

1.5 REFERENCES

- 1.5.2 American National Standards Institute/Air-Conditioning and Refrigeration Institute (ANSI/ARI)
 - 1. ANSI/ARI 430, Central Station Air Handling Units.
 - 1.5.3 Canadian General Standards Board (CGSB)
 - 1. CAN/CGSB 1.181, Ready-Mixed Organic Zinc-Rich Coating.
 - 1.5.4 Canadian Standards Association (CSA)
 - 1. CSA B52, Mechanical Refrigeration Code.
 - 1.5.5 Sheet Metal and Air-Conditioning Contractors' National Association (SMACNA).
 - 1.5.6 American Bearing Manufacturer's Association (ABMA)
 - 1. ANSI/ABMA 9 Load Ratings and Fatigue Life for Ball Bearings
 - 2. ANSI/ABMA 11 Load Ratings and Fatigue Life for Roller Bearings.
 - 1.5.7 Air Movement and Control Association (AMCA)
 - 1. AMCA 210, Laboratory Method of Testing Fans for Aerodynamic Performance Rating (ASHRAE)
 - 2. AMCA 300 Reverberant Room Method for Sound Testing of Fans.
 - 1.5.8 American Society of Heating Refrigeration and Air-Conditioning Engineers (ASHRAE).
 - 1. ASHRAE 68, Laboratory Method of Testing to Determine the Sound Power in a Duct.
 - 2. ANSI/ASHRAE 90.1, (I-P) Energy Standard for Buildings Except Low-Rise Residential Buildings.
 - 3. ANSI/ASHRAE 52.2, Method of Testing General Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Size.
 - 1.5.9 National Electrical Manufacturer's Association (NEMA)
 - 1. NEMA MG1 Motors and Generators
 - 2. NEMA ICS 7-1 Safety Standards for Construction and Guide for Selection, Installation and Operation of Adjustable Speed Drive Systems.
 - 1.5.10 Provincial Boiler, Pressure Vessel and Compressed Gas Regulations.
- 1.6 SHOP DRAWINGS AND PRODUCT DATA**
- 1.6.2 Submit shop drawings and product data in accordance with Section 01 33 00 - Submittal Procedures.

- 1.6.3 Indicate following: fan, fan curves showing point of operation, motor drive, bearings, filters, mixing box, dampers, VAV, coil, include performance data.

1.7 CLOSEOUT SUBMITTALS

- 1.7.2 Provide operation and maintenance data for incorporation into manual specified in Section 01 78 00 - Closeout Submittals.
- 1.7.3 Include following: fan, bearings, motor, damper, VAV control, air volume, total cooling, sensible cooling, EDB, EWB, OAT.

1.8 WASTE MANAGEMENT AND DISPOSAL

- 1.8.2 Separate and recycle waste materials in accordance with Section 01 74 21 - Construction/Demolition Waste Management and Disposal, and with the Waste Reduction Workplan.
- 1.8.3 Remove from site and dispose of packaging materials at appropriate recycling facilities. Collect and separate for disposal paper, plastic, polystyrene, corrugated cardboard, packaging material in appropriate on-site bins for recycling in accordance with Waste Management Plan.
- 1.8.4 Divert unused metal and wiring materials from landfill to metal recycling facility approved by Owner.
- 1.8.5 Divert unused paint material from landfill to official hazardous material collections site approved by Owner.
- 1.8.6 Do not dispose of unused paint materials into sewer systems, into lakes, streams, onto ground or in other locations where it will pose health or environmental hazard.

1.9 EXTRA MATERIALS

- 1.9.2 Provide maintenance materials in accordance with Section 01 78 00 - Closeout Submittals.
- 1.9.3 Provide one spare set of filters.
- 1.9.4 Provide list of individual manufacturer's recommended spare parts for equipment such as bearings and seals, and addresses of suppliers, together with list of specialized tools necessary for adjusting, repairing or replacing, for placement into operating manual.
- 1.9.5 Spare filters: in addition to filters installed for startup and commissioning. Immediately prior to acceptance by Owner, supply 1 complete set of filters for each filter unit or filter bank.

2 PART2 PRODUCTS

2.1 GENERAL

- 2.1.2 Factory assembled components to form units supplying air at designed conditions, as indicated.
- 2.1.3 Certify ratings: to ARI 430 with ARI seal.
- 2.1.4 Horizontal and vertical type, as indicated, having air tight modular components, consisting of casing, fan section with motor and drive, filter section, dampers, bypass section, heating coil, cooling coil, humidifier, spray section, mixing box, blender air mixing device or filter mixing box.

2.2 CASINGS

- 2.2.2 Galvanized or phosphate treated steel 1.6 mm thickness outer casing reinforced and braced for rigidity.
 - 1. Walk-in access doors: provide access for maintenance of internal parts with wired glass 200 x 200 mm viewing port or 200mm diameter polycarbonate double porthole.
 - 2. Paint steel parts, where not galvanized, with corrosion resistant paint to CGSB 1.181.

3. Finish structural framed units, inside and out, with rust resistant enamel to Section 09 91 13 – Exterior Painting.
- 2.2.3 Line entire casing with minimum 1 mm thick, solid galvanized, steel liner.
- 2.3 DRAIN PANS
 - 2.3.2 Construction: stainless steel, plastic or FRP, rounded corners, double wall.
 - 2.3.3 Insulation: extruded foam type, minimum 13 mm thick.
 - 2.3.4 Drain connection: in bottom at low point.
 - 2.3.5 Installation: slope without sag minimum 1% to ensure no standing water at any time or at any point.
 - 2.3.6 Dimensions: minimum 75 mm from upstream face of coil to 150 mm beyond downstream face of coil or eliminator and to include return bends and headers.
- 2.4 FANS
 - 2.4.2 Cabinet hung or frame mounted AMCA-rated for sound and performance, centrifugal fans with backward inclined or airfoil wheels, selected to operate in stable part of performance curve and heavy duty L10 100,000 hours minimum service self aligning or split pillow block bearings.
 1. Provide internally mounted motor as indicated complete with adjustable V-belt drive and guard.
 2. Motor: see schedule.
 - 2.4.3 Maximum sound power levels, as indicated.
- 2.5 VIBRATION ISOLATION
 - 2.5.2 Flexible connections at inlet and outlet of fan section: to Section 23 33 00 – Air Duct Accessories.
 - 2.5.3 Vibration isolators on fan section: to Section 23 05 48 - Vibration and Seismic Controls for HVAC Piping and Equipment.
- 2.6 VARIABLE VOLUME DEVICES
 - 2.6.2 Adjustable inlet vanes operated from centre mechanism linked to each damper vane or cantilevered vane mechanism as indicated.
 1. Support vanes in self-lubricated bronze bearings.
 2. On DWDI fans interconnect vanes to operate simultaneously.
 3. Provide locking devices for manual operation.
 - 2.6.3 Variable fan width sleeve mechanism with control linkage as indicated.
 1. For DWDI fans, provide interconnected linkage to operate simultaneously.
 2. Provide locking devices for manual operation.
 - 2.6.4 Variable speed drives as indicated: motors to be suitable for variable speed drive. Variable speed drives in accordance with Section 26 29 10 – Motor Starters to 600 V.
- 2.7 FILTER BOX
 - 2.7.2 Material to match casing. For flat plus rigid type filter arrangement.
 1. Provide access to filter through hinged door with suitable hardware.
 - 2.7.3 Provide blank-off plates and gaskets to prevent air bypass.
 - 2.7.4 Filters: to Section 23 40 00 – HVAC Air Cleaning Devices.
- 2.8 MIXING BOX
 - 2.8.2 Material to match casing and produce uniformly mixed air temperature within plus or minus 5 °C of design across face of outlet.
 - 2.8.3 Dampers:
 1. Dampers for mixing boxes: to Section 23 33 15 - Dampers - Operating.
- 2.9 BLENDER STATIC AIR MIXING DEVICE
 - 2.9.2 General:

1. Pre-engineered device with no moving parts, designed to thoroughly mix warm and cold air streams, to within 3° C at 40 Pa pressure drop and to provide for even velocity distribution profile.
2. Sizing criteria:
 - 2.9.2.2.1 Type: static.
 - 2.9.2.2.2 Size: to suit unit mixing box at mixer area to plenum area of 0.4, and minimum flow rate to maximum flow rate of 0.4 plenum, velocity 2.5 m/s
 - 2.9.2.2.3 Pressure drop: 40 Pa.
 - 2.9.2.2.4 Capacity:
 - 2.9.2.2.4.1 Outside air: as indicated.
 - 2.9.2.2.4.2 Return air: as indicated.
 - 2.9.2.2.5 Mixed air temperature: 12°C at outside air to supply air ratio of 0.25.
- 2.9.3 Construction:
 - 2 mm thick aluminum or 1.6 mm thick stainless steel.
- 2.9.4 Blender section:
 1. Blender in housing ready for insertion into air handling unit.
 2. 50 mm flanges on inlet and outlet.
 3. Complete with 25 mm, 32 kg/m³ density, fibreglass lining and insulated access door.
- 2.9.5 Blender mixing box:
 1. General: single unit consisting of dampers, blender, mixing section, with provision for floor mounting.
 2. Construction: stainless steel duct connection flanges, reinforced for rigidity, finished with corrosion resistant paint or zinc coating.
 3. Dampers: parallel blade, low leakage, proportioning type.
 - 2.9.5.3.1 Leakage: not more than 50 L/s.m² at 750 Pa.
 - 2.9.5.3.2 Seals: Neoprene on damper edges, top, bottom, sides of framing.
 4. Blades of 1.6 mm thick steel, 150 mm maximum wide, locked to steel rods in rustproof bushings.
- 2.10 COILS
 - 2.10.2 Capacity: see schedule.
 - 2.10.3 Ratings: ARI certified.
 - 2.10.4 Construction:
 1. Casings: 1.5 mm thick galvanized sheet steel.
 - 2.10.4.1.1 Supports of galvanized steel channel or double angle frames.
 - 2.10.4.1.2 Blank-off plates. Insulated sandwich construction.
 2. Non-freeze steam coils: tube-in-tube type with internal perforated steam distributing tubes. Slope tubes to drain condensate.
 - 2.10.4.2.1 Tubes: copper, brass or steel.
 - 2.10.4.2.2 Fins: aluminum.
 - 2.10.4.2.3 Headers: cast iron, steel or cast brass.
 - 2.10.4.2.4 Pressure tests: 1.7 MPa.
 3. Steam coils: single tube type.
 - 2.10.4.3.1 Tubes: copper, brass or steel.
 - 2.10.4.3.2 Fins: aluminum.
 - 2.10.4.3.3 Headers: cast iron, steel or cast brass.
 - 2.10.4.3.4 Pressure tests: 1.7 MPa.
 4. Hot and Chilled water coils: cleanable fins.

2.10.4.4.1 Tubes: copper, brass or steel.

2.10.4.4.2 Fins: aluminum plate or spiral wound.

2.10.4.4.3 Headers: cast iron, steel or cast brass.

2.10.4.4.4 Pressure tests: 1.7 MPa.

5. Direct expansion refrigerant coils:

2.10.4.5.1 Serpentine type, arranged to prevent trapping of oil.

2.10.4.5.1.1 Liquid distributors to ensure even distribution of liquid refrigerant to all circuits.

2.10.4.5.1.2 Silver solder or braze joints in refrigerant tubing.

2.10.4.5.1.3 Evacuate and charge coil with nitrogen and seal before sending to site.

2.10.4.5.2 Tubes: copper.

2.10.4.5.3 Fins: aluminum, plate or spiral wound.

2.10.4.5.4 Headers: copper.

2.10.4.5.5 Pressure tests: CSA B52 and carry a Canadian Refrigeration Number. Dehydrated. Sealed with nitrogen charge.

2.11 HUMIDIFIERS

2.11.2 To Section 23 84 13 - Humidifiers.

2.12 HEAT RECLAIM DEVICES

2.12.2 As indicated and as per Section 23 72 00 – Air-to-Air Energy Recovery Equipment.

3 PART3 EXECUTION

3.1 INSTALLATION

3.1.2 Install units in accordance with manufacturer's instructions and as indicated.

3.1.3 Ensure adequate clearance for servicing and maintenance.

3.2 FANS

3.2.2 Install fan sheaves required for final air balance.

3.2.3 Install flexible connections at fan inlet and fan outlets.

3.2.4 Install vibration isolators.

3.3 DRIP PANS

3.3.2 Install deep seal P-traps and trap seal primer on drip lines.

1. Depth of water seal to be 1.5 times static pressure at this point.

3.4 COMMISSIONING

3.4.2 Commission in accordance with Section 01 91 13.13 – Commissioning (Cx) Requirements one day per unit for startup and one day for commissioning.

END OF SECTION

SECTION 23800000:

VRF SPECIFICATIONS

PART 1 GENERAL

1.1 RELATED DOCUMENTS

1. Drawings and general provisions of Contract, including General and Supplementary Conditions and Divisions, HVAC specification Sections, apply to work of this Section.
2. The requirements of this Section apply to equipment specified elsewhere in the specification.
3. Electrical Conditions and specifications

1.2 DESCRIPTION OF WORK

1. The work includes the providing of all labor, supervision, materials, equipment, accessories, services and tests necessary to complete and make ready for operation by the Owner.

1.3 QUALITY ASSURANCE

1. Manufacturers: Firms regularly engaged in manufacture of units, types, materials and sizes required, whose products have been in satisfactory use in similar service for not less than 5 years. Provide equipment produced by a manufacturer listed as an Acceptable Manufacturer in this section. Furnish all equipment from one manufacturer.
2. Standards Compliance: Comply with requirements of applicable local codes and the following:
 1. ARI or Eurovent: Certify that the capacities of each model and size is in compliance with industry standard 440-89 for Indoor Units or any equal approved certification.
 2. ARI: Test and rate each model and size for sound in accordance with industry standard 443-71 for sound ratings of Indoor Air Conditioners.
 3. ARI 210 - Unitary Air-Conditioning Equipment.
 4. ARI 270 - Sound Rating of Outdoor Equipment.
 5. Guarantee each unit to operate at the certified sound levels. Replace any unit, which does not fulfill this requirement.
 6. A certified VRF installer should install, connect, test and balance the VRF system complete with its associated piping and insulation work, and the local VRF agent should commission & startup the system at cost of installer. Certificate or approval for installer by local agent and a certificate that installer possess all required tools (list should be submitted) is a must. Technicians should also be trained and certified for VRF installation by Factory Engineer. None certified installers or technicians are not allowed or accepted.
 7. The units shall be manufactured in a facility registered to ISO 9001 and ISO14001 which is a set of standards applying to environmental protection set by the International Standard Organization (ISO).
 8. Both Indoor and outdoor units shall be manufactured in the manufacturer's factory and tested under high quality control to ensure compatibility, reliability and performance.
 9. R410A refrigerant as stated amount in the catalogue shall be charged and shall be checked by leakage test in factory.
 10. The units shall be manufactured and designed to standards relating to quality assurance under ISO9000, ISO9001 and EN ISO14001. Also be fully compliant with Standard for Heating and Cooling Equipment ANSI/UL 1995

3rd Ed. and CAN/CSA C22.2 236-05, CAN/CSA-C749-94. ANSI/AHAM DH-1-1992. CAN/CSA-C273,3-M91. And TUV according to ISO/ICE 17025 .and EN/ICE 60335-1, EN/ICE 60335-2-40

1.4 SUBMITTALS

1. Product Data: Submit manufacturer's product data, including printed technical literature, and catalog cuts for each type of Indoor Unit and Outdoor Unit or computer selection printout indicating connection details, dimensions and required clearances, and installation instructions.
2. Schedule: Submit a schedule showing manufacturer, models, sizes, and capacities for approval before ordering the equipment.
3. Shop drawings including piping, joints and header with complete sizing and dimensions for the VRF system
4. Provide method of statement for the installation, connection, testing, balancing and commissioning of the VRF units.
5. Provide startup recording (graphical and tables) using service checker equipment for a startup of VRF system (showing date, site name and successfully operating for more than Five years).
6. Provide List of projects in Egypt indicating number of indoor units, outdoor units, special central control, project name, location and total operational units in Egypt (for same brand provided in offer).
7. Provide a list of Factory Trained engineers on VRF installation and startup showing, name of engineer, description of courses attended, and experience in installation and service of VRF projects (for same brand provided in offer). Certificates of Factory Training and Certificates of excellence for VRF engineers.
8. List of tools used for VRF installation and maintenance including specifications and catalogue cut of equipment and tools. Tools must be submitted or be available for inspection prior to approval of submittal.
9. Maintenance center tools and proof or previous usage and list of factory certified engineers and technicians to work on tools with relevant maintenance courses.
10. Previous Certificates of excellence in installation and maintenance of VRF system (of same brand provided in offer)
11. Provide List of Spare parts available at Local Agent
12. Provide stock available of similar units used in project available at local Agent.
13. Provide List of VRF projects of same brand in Last Three years.
14. Provide List of VRF Projects of same brand under execution.
15. Provide Local Training VRF Facility availability
Items E to Item O should be presented to engineer or available for inspection at installer and agent facilities prior of approval of submittal.

PART 2 PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

See vendor list

2.2 PERFORMANCE OBJECTIVES

1. The VRF plant is installed to maintain environmental conditions within the areas allocated to be Air Conditioned to the design parameters listed below.

Design Parameters:

- 1) Room Temperature $23^{\circ}\text{CWB} \pm 0.5^{\circ}\text{C}$

2)	Ambient Temperature	(Summer)	46°C
3)	Ambient Temperature	(Winter)	7°C
4)	Room Noise Level	NR38	

2.3 GENERAL SYSTEM DESCRIPTION

1. The VRF heat pump systems shall be installed to provide heating or cooling to the areas via individually controlled room units on the same refrigeration circuit. The outdoor equipment shall be Air Cooled Modular Design Variable Refrigerant Volume (VRF) systems.
2. The VRF indoor & outdoor units should be complete with scroll compressors, fans, condenser, heat exchanger, electronic expansion valve with 2000 control steps, control cables & all other accessories, as per manufacture recommendations.
3. The VRF system shall be an Inverter Driven 2 Pipe Heat Pump system, which operates on energy efficient R410A refrigerant. See attached schedule for details of equipment in project.
4. Each system shall be based on one modular outdoor air cooled condensing unit connected via a single refrigerant circuit comprising suction and liquid pipe work for up to 64 indoor fan coil units, of different types and capacities. The total load of which should not exceed the total outdoor unit's capability index.
5. The systems shall be capable of operating when ambient temperatures vary between 48°C and -5°C in cooling mode and between -20°C and 15.5°C in heating mode. The internal temperature control range is between 16°C and 30°CWB.
6. All Concealed indoor units must be complete with variable speed fan.
7. The system should have an integrated oil recovery system, no oil traps are allowed
8. The system should have Automatic refrigerant charging, Automatic leak detection & Auto addressing functions
9. Outdoor units with frequency control from 15 HZ to 150 HZ, the outdoor units should not have an equalizing pipe between the outdoor modules
10. The unit's sound level should not exceed 63 dB(A)
11. The refrigerant pipe work circuit can be extended up to 165 meters actual (190m equivalent length) between the outdoor condensing unit and the furthest indoor unit on the circuit and may incorporate a 90 meters level difference without no oil traps., Piping should be extendable to 40metres from the first branch . The level difference between indoor units on one system can be to 15 meters and total piping network in single system can be up to 1000 meters.
12. Operation of the system shall permit either cooling or heating of each fan coil or all of the fan coil units serving a common room. Each fan coil or group of fan coils shall be able to provide set temperature independently via a local remote controller, an Intelligent Controller, an Intelligent Manager or a BMS interface.
13. The system shall operate with Refrigerant HFC R410A (R32/R125 (50/50)), the installation to be in accordance with BS EN378: 2000 Parts 1-4 and Manufacture's design and installation instructions listed in the VRF Installation Instructions, and Serviced in accordance with service manual.
14. Also be fully compliant with CE Regulations 1995 with respect to the following areas
 - a. MSD89/392/EEC – Machine Safety Directive, LVD73/23/EEC – Low Voltage Directive, and EMC Directive EMV89/336/EEC – Electro-Magnetic Compatibility, and PED conformity.

2.4 VRF INDOOR UNITS (Manufactured in Korea, Japan & Europe only)

Indoor unit shall consist of a fan, a heat exchanger and an electronic proportional expansion valve which shall be controlled via computerized PID control which constantly, every 20 seconds measures and assesses the status of the return air temperature, refrigerant inlet and outlet temperature.

During the cooling operation the electronic expansion valve (not less than 1500 steps) shall control the degree of refrigerant superheat at the evaporator outlet. During the heating operation it shall control the degree of refrigerant sub cooling at the condenser outlet.

The indoor unit printed circuit board shall be complete with power input fusing, address switches for a variety of operation controls, emergency operation switch and fault/operation indication LED's. Fan motors shall be thermally protected.

All Concealed indoor units must be complete with variable speed fan. The indoor unit casing of ceiling concealed and cassette types, shall be fully insulated and sealed to prevent condensation. The insulation shall conform to BS476 Part 7 fire rating.

All indoor units should have a Multi-Tenant option which useful in an apartment building, where multiple tenants share one outdoor unit.

A. General

1. Provide the required units, types and capacities shown in the design schedules, BQ and Drawings to fulfill designed load at actual capacities.
2. Submit a computer selection showing pipe size and length.
3. Provide a certificate that the system limitations are not violated or exceeded.
4. All units shall be of the cooling/ heating type using the heat pump technique
5. Combination ratio should be maximum 130 %. Subject to manufacturer approval depending on territory and application and ambient temperature.
6. Unrestricted positioning of the indoor units shall be at least 195m pipe run allowance with a height difference of 90 m from the outdoor unit and up to 15m among the indoor units and up to 90 meters for a single indoor and up to 1000 meter in single circuit.
7. Units shall be provided with low noise direct drive fan, motor, heat exchanger, electronic expansion valve, drain pump built in for concealed & cassette models insulated drain pan and refrigerant filters.

B. Medium Static Concealed ceiling unit

1. VRF indoor type (false ceiling duct connection) unit with external static pressure for cooling (by evaporator) or heating (by condenser) by use of refrigerant.
2. The air can be taken in either through an optional, white, washable panel fitted with a washable long-life filter or through an air duct. The air is expelled through a fixed installation duct. The indoor unit should be compatible with the inverter outdoor unit.
3. Fresh-air admixing of 10-15% in relation to the nominal flow rate can be admixed via a punched aperture (diameter 125mm).

C. Radial fan

Vibration-free and quiet running. Protected by a thermal contact.

D. Air Cooler / Heater

Large surface area with HI-X Cu piping with profiled aluminium vanes. R410a counter flow design. Coil no less than 3-rows deep, fabricated of 15mm O.D. copper tubes and aluminum fins mechanically bonded to the tubes.

E. Electronic Expansion Valve

With stepping motor, 2000 steps for precise cooling unit adjustment between 0%-100%. This prevents large temperature differences between room temperature and discharge temperature at partial loading.

F. A drain pump

Is integrated into the unit as a standard fitting. Drain-up height 0.50 m. In units High Static Pressure, Wall Mounted and Ceiling Suspended Units, drain pump to be considered as variation subject to Architectural requirements and approval.

G. Micro-Processor Controlled

Capacity-dependent refrigerant supply, controlled by minim 3 thermostats (set temp., heat exchanger sensor (intake/outlet)) and a PID controller, operating mode dependent fan control, self-diagnosing, malfunction code acquisition and evaluation, information system for servicing. Adjustment programming deviant from the factory setting, e.g.

1. Floating contacts suitable for use in BUS systems (LON-BUS, EIB) are programmable as an external ON/OFF, emergency stop or window contact.
2. Malfunction code history for troubleshooting
3. Forced fan operation with multi model applications
4. All PID controller thermistors can be polled

H. Bus Systems

An interface connection is provided for connection to the main bus systems (LON Bus, EIB Bus). The most important data are transferred via this.

I. Control Extensions and options:

1. LONWorks, BACNET and Open Protocol TCP/IP interface,
2. Additional KRP 4A51(FXYCP/KP/SP/ KRP 4A53 (FXYFP/BP/MP/HP/APLP/LMP) PCB, for integration in GLT (see LV text),
3. Additional KRP 2A51(FXYCP/KP/SP/BP/MP/LP/LMP), KRP 2A53 (FXYFP/HP/AP) PCB, for integration in GLT (see LV text),
4. Additional KRP 1B61(FXYCP/KP/SP/BP/MP/HP/LP/LMP), KRP1B2(FXYFP) KRP1B3(FXYAP) PCB, for integration in GLT (see LV text),
5. Additional DCS302A52 PCB, to integrate in GLT in conjunction with centralised control modules or DBACS systems (see LV text),
6. Centralised switch panel module,
7. Parallel interface with 2 additional modules (set temperature and read temperature),
8. Central Intelligent management system.

The following remote controls should be available for connection with indoor units upon requirement and engineer request (as option) :

1. Hotel remote control Type I (with mode selector, flush mounted for mounting in
2. the corpus of built-in cupboards): BRC2A51

3. Hotel remote control Type II (without mode selector, flush mounted for mounting in the corpus of built-in cupboards): BRC3A61
4. Wireless remote control (separate receiver installed in the room): BRC4C62
5. Unified ON/OFF controller for 16 Indoor groups

- J. CE Declaration of Conformity
Comprising LVD73/23/EEC, EMV89/336/EEC and MSD89/392/EEC

2.5 OUTDOOR UNIT

1. The outdoor condensing units shall be completely weather proofed to corrosion resistant type E1. Factory assembled in a sturdy weatherproofed casing constructed from rust-proofed mild steel panels (Galbarian Steel) coated with an electro-painted oven baked enamel finish. Also pre-charged, pre-wired and completed with all necessary electronic and refrigerant controls for ease of installation and factory tested and can be connected to up to 64 units.
2. The modules are combined using the 2 piping connection for liquid and gas pipes only without oil equalising pipe. Units should be same height and depth to be installed in rows.

2.6 GENERAL

1. Units of weather proofed, anti-corrosion enclosure, complete with compressors, fans, motors and condenser coils
2. Hermetically type Scroll inverter compressor with one moving part and oil filter. Rotary or Twin Rotary compressors with more than one moving part are not allowed.
3. Liquid receiver: The system should have an integrated oil recovery system, no oil traps are allowed
4. Oil equalizer system between compressors and condensers.
5. Maximum size unit shall be designed to work with several indoor units (up to 64 units) connected to the same refrigerant circuit
6. Automatic control system shall handle the conditions of the operation of any number of indoor units down to one, the frequency of the inverter control to be determined electronically by sensing ambient temperature, operational pressures and monitoring the exact requirements of all the connected indoor units.
7. Ambient temperature should range from -5 C Dry Bulb Temp.(DBT) to 48 C DBT in the cooling operation and from -5 C Wet Bulb Temp.(WBT) to 15.5C WBT in the heating operation
8. The system should have Automatic refrigerant charging, Automatic leak detection & Auto addressing functions
9. The units to be equipped with the back-up function, which allow the other outdoor units to operate as emergency to prevent the total shutdown of the system, even when one of the outdoor unit goes out of order.
10. Outdoor units with frequency control from 15 HZ to 150 HZ, the outdoor units should not have an equalizing pipe between the outdoor modules
11. Units shall be capable of controlling running hours of compressors to ensure the same lifetime.
12. System should be have high COP (ex. Not less than 4.5 on size 24HP and 4.35 on size 36 HP and 3.7 on size 54 HP).

2.7 OUTDOOR UNITS

The VRF indoor & outdoor units should be complete with scroll compressors, fans, condenser, heat exchanger, electronic expansion valve with 2000 control steps,

control cables & all other accessories, as per manufacture recommendations

A. Module heat exchangers

High-capacity condenser/evaporator, optimised for R410A refrigerant. Less refrigerant charge through compact construction with Hi-X Cu seamless piping in counter-flow design and N-shape internal grooves, with e-Pass circulation to achieve greater refrigerant sub-cooling for long piping runs. Specially profiled aluminium vanes, achromatised and plastic coated for surface protection against corrosive air, acid rain and saline air (e.g. for installations in coastal regions) to extend the overall useful life.

1. The fins are to be covered with an anti-corrosion Acrylic resin and hydrophilic film type E1. The pipe plates shall be treated with powdered polyester resin for corrosion and rust prevention.
2. The heat exchanger should be approved and tested according to:

a) VDA Weichsel test:

Where the plate passes 5 cycles of 7 days each containing:

- 24 hrs. of salt spray test SS DIN 50021
- 96 hrs. humidity cycle test KFW DIN 50017
- 48 hrs. room temperature & room humidity testing period (5 cycles)

b) Kestrinich test:

Where the plate passes 40 cycles of 48 hrs each tested according to DIN 50017.

2.8 FAN

The outdoor fan impeller shall be of aero spiral type for vertical air discharge, designed for low noise operation with manipulation on the fan blade edges to reduce turbulence and have a aero fitting discharge grill. The fan motor shall be DC (Digital Commutator brushless motor) inverter speed control to maintain constant head pressure control in all ambient conditions and modes of operation. Fan motors shall have external static pressure of 78Pa.

Number of Aero-Spiral-Fans (Two fans only for size 14-18 HP, Three fans for size 26-48 HP and Maximum of Six Fans in Size 54 HP).

2.9 COMPRESSOR (PER MODULE)

1. The compressor shall be of the high-efficiency Hermetically Sealed Reluctance DC (Digital Commutator brushless motor) Scroll type (rotary or twin rotary are not allowed) with only one moving part employing neodymium magnets with gas fed directly to the compression process.
2. The motor should be cooled by pressurized gas not by suction gas or evaporation of the refrigerant in the motor to prevent overloading of winding and bearings which is cases by sporadic jumps in temperature if suction gas is used for cooling.
3. Compressor should have no accumulator, rotary or twin rotary compressors with more than one moving part are not accepted.
4. Each outdoor unit shall have at least one inverter driven compressor electronically controlled and capable of changing the speed linearly to follow the variations in cooling or heating load. In the cases of two or more compressors there shall be duty balancing. This shall be by the use of HIDECS

circuit (Hi Inverter Drive and Electronics Control System) together with independent multi-variable PI (Proportional Integral) control for the precise monitoring of status of the system. With optimum capacity control of one or two standard drive compressors in accordance with load. All compressors should be fitted within the unit on anti-noise mountings.

5. Capacity control of the outdoor unit shall be inverter controlled with following steps for Single Module: 20 steps for size 5 HP, 25 steps for size 8 HP, 25 steps for size 8 HP, 37 steps for size 10&12 HP, 51 steps for size 14&16 HP, 55 steps for size 18 HP and Minimum 67 steps for the 54 HP size (with maximum Three Modules). The frequency of inverter control shall be determined electronically by sensing ambient temperatures, operational pressures and monitoring the exact requirement of all of the connected indoor units, frequency should be controlled from 52 HZ to 266 HZ.
6. Modules 5-18 HP each should include at least an inverter compressor with DC motor (digitally commutated brushless DC motor), which is frequency controlled. This should be done by converting AC voltage to DC voltage, using a rectifier and producing an independent controlled frequency. Mains frequency and unit frequency should be de-coupled in the inverter.
7. There should be no residual frequencies and electromagnetic compatibility (EMC) should be complied without restriction. Adherence to the directive EMV89/336/EEC is a must.
8. To prevent a lack of oil, dynamic oil balancing system should be applied by fitting to the inlet side and a large surface area oil separator should be installed on the outlet side.
9. To optimize the supply of lubricant for several compressors, an automatic oil return cycle for the whole of the system network should be periodically activated by the MICRO-PROCESSOR system controller.
10. No oil filters are allowed in the system.
11. The compressor, the electrical and thermal motor protection and the oil sump heating should be controlled by the MICRO-PROCESSOR system controller
12. The unit's sound level should not exceed 63 dB(A)
13. Sizes 5&8 HP should contain one inverter compressor, Sizes 10&12 should contain One Inverter and One Fixed speed compressor and Sizes 14-18 HP should have One Inverter compressor and two fixed speed compressors.

2.10 COOLING CIRCUIT (PER MODULE)

The refrigeration circuit of the outdoor unit shall include a SCe-Bridge Circuit complete with solenoid valves, 4 way valve(s), distribution headers, and capillaries, filters, shut off valves, service ports and receivers.

1. And should be optimised for the use of R 410 A refrigerant. Cooling circuit should comprise refrigerant collector, filter and oil separator.
System should optimise level of fill for the evaporator and overheating control for the heating mode by way of an electronic injection valve (EEXV) with 2000 servo steps, controlled by the Micro-processor system controller.
2. Dynamic E-Bridge circuit for optimum refrigerant sub-cooling, in addition to circuit for stabilising the liquid pressure and the head of liquid in refrigerant collector.

2.11 CONTROL AND SAFETY DEVICES:

Control sensors should be builtfor

1. low pressure
2. high pressure
3. refrigerant suction temperature
4. oil temperature
5. heat exchanger temperature
6. Outside temperature.

Safety pressure switches should be for low and high pressure (manual reset should be possible from remote control).

The unit should be equipped with shut-off valves for suction and liquid pipes and service connections with Schrader valves. The refrigerant circulation is dried, evacuated and charged with the required refrigerant.

For selected sizes, subject to variations in site, zoning or application changes, Engineer can require same capacity unit from manufacturer during constructions (but bigger/smaller footprint and weight or with higher efficiency) prior to approval of submittal or during construction.

2.12 MICRO-PROCESSOR SYSTEM CONTROLLER

Micro-controller supported control and regulation of the process sequence for both cooling and heating operating modes. Management function for all sensors and actuators, control and safety components and electrical drives.

2.13 MANAGEMENT OF BASIC FUNCTIONS:

1. Pam-Sinus Inverter Control: Continuous compressor capacity control as required.
2. E-Bridge function: optimum refrigerant sub-cooling and collector level of fill control
3. Oil Balance Circuit dynamic oil balancing system
4. Oil Return Function: dynamic oil return mode
5. Auto Restart: automatic restart after power failure
6. Auto Initialisation: automatic detection and addressing of the indoor units on the system bus

2.14 MANAGEMENT OF INDIVIDUAL FUNCTIONS:

1. Low-Noise Operation: Noise-reduced operation, night time operation
2. i-Demand: electrical peak load limiting and compressor sequence run-up
3. Sequence start: automatic run-time compensation between compressors
Several modules (from size 18 upwards)
4. Adaptation of the evaporation and condensation temperatures and outdoor temperature

Unit should have Self-diagnosis function for outdoor and indoor units over the communication data bus with operator access via the local manual operating level and/or via the diagnosis tool: Service-Checker - presentation and storage of all process parameters for effective system maintenance. Including maintenance protocol print out

2.15 AUTO CHECK FUNCTION:

1. The system shall employs the Auto check function for connection errors of the unit wiring and piping, to be shown on the PC board in the outdoor unit.

2. The system should record the last 5 minutes of operating data continuously to enable the analysis of the data in case of any malfunction to identify the problem cause.

2.16 AUTO REFRIGERANT CHARGE FUNCTION:

The system shall have an automatic refrigerant charge function capable of calculating required additional refrigerant charge due to pipe length and diameter and automatically adjust required additional charge.

2.17 AUTO LEAK DETECTION FUNCTION:

A leak detection feature that automatically calculates the volume of the refrigerant flowing in the cycle depending on reference values of system's temperatures, pressures & refrigerant density & the types & number of indoor units.

2.18 AUTO ADDRESS FUNCTION:

The system should be capable of performing Auto address for indoor units without using dip switches or rotary switches. Manual addressing is not allowed.

2.19 ANTI-RECYCLING TIMERS.

The condensing units shall be capable of sequential start when more than one unit is installed to minimize circuit breakers size and current.

2.20 AUTO RESTART FUNCTION:

Unit should have an auto restart capability after power failure as standard.

2.21 BACK-UP FUNCTION.

1. If a compressor failure occurs in system the remaining compressors ensures at least 66% system capacity for Three modules units. This function is activated at the outdoor unit.
1. If a compressor fails in a module in two or three module systems (module sizes 20-54 HP), this module can be de-activated. The remaining module or modules then keep uphold the basic supply.
2. The operator should be able to use the remote control to activate this function.

2.22 OIL RECOVERY FUNCTION

The oil recovery cycle shall be automatic, occurring 1 hour after start of operation and then every 8 hours of accumulated operation. Oil separators should be standard with the equipment together with oil equalization system between compressors and condenser, no oil traps are allowed.

2.23 OPTIMISATION AND OPERATIONAL SAFETY FUNCTIONS:

When the system is initially commissioned, it operates in an automatic operating mode and creates the individual system characteristic curve for optimum partial load operation. The respective structural conditions (pipe network resistance, differences in height) are acquired during this operating mode. This dynamic system pressure loss flows into the target pressure calculation as a variable (evaporation temperature). This ensures a constant pressure and thus constant temperature level at the heat exchangers, independent of partial load.

2.24 ELECTRONICS

1. The outdoor electronic PCB's shall be lead free with emergency operation switches, and service mode switches, together with LED indications for the

- number of fan coils connected, the frequency status and operational/fault indication. The control circuit shall have a pump down facility to enable collection of the entire refrigerant charge in the system at the outdoor unit.
2. The units shall have microprocessor control system incorporated to enable oil return, stability of refrigerant flow and capacity balancing.
 3. The following safety devices shall be part of the outdoor unit;
 1. High- and low-pressure switches,
 2. Control circuit fuses,
 3. Crank case heaters,
 4. Thermal protectors for compressor and fan motors,
 5. Over current protection for inverter

2.25 CE DECLARATION OF CONFORMITY

Should comply with The Low Voltage Directive LVD73/23/EEC, EMC Directive EMV89/336/EEC and Machine Directive MSD89/392/EEC.

2.26 CONTROLS

LOCAL SYSTEM CONTROLS

1. The controls system shall include all necessary Manufacture remote controllers and interface PCB's.
2. Remote controller shall be provided per room/Zone or fan coil as specified and be capable of controlling an individual fan coil or group of fan coils, up to 16 indoor units. Also unified ON/OFF controllers each to control up to 16 indoor units and Central controller to control up to 64 indoor units.
3. The controller shall have a liquid crystal display and provide the following facilities:
 1. Temperature setting
 2. Fan speed setting
 3. Mode setting fan/cooling
 4. On/Off control
 5. Diagnostics Feedback
 6. 7 Day Timer Function
4. Remote air sensors shall be provided for local room sensing where fresh air is introduced to the fan coil unit. To be positioned within the room or close to the return air grill in the ceiling.
5. Air Conditioning Central Management System

2.27 INTELLIGENT TOUCH CONTROLLER

All the air conditioning systems shall be controlled by an intelligent Touch Controller system (windows operating system) with full colour LCD touch panel and Icon display or List display, optional with Power Proportional Distribution Function (PPD) for individual billing. With the following functions;

1. Automatic cooling/heating changeover
2. Heating optimization
3. Temperature limit
4. Yearly schedule
5. Power Proportional Distribution (optional)
6. Fire emergency stop control
7. Flexible timer functionality (several schedules up to a full year)
8. Flexible grouping in zones

9. Historical data
10. Password security levels
11. Connectable to Manufacture Sky Air & Splits via an interface adapter
12. Operation of up to 64 groups of indoor units (with maximum 128 indoor units)
13. Web enabled (optional).

1. Control Module: Remote mounted adjustable thermostat with heat anticipator, off- heat-auto-cool switch, high-low fan switch.
2. The system use the PID control technology to provide temperature + 0.5 C from the room set point
3. The units shall be equipped with the auto restart function after power failure.

PART 3 EXECUTION

3.1 INSPECTION

Examine area and condition under which the indoor VRF units are to be installed. Notify the engineer in writing of conditions detrimental to proper completion of the work. Do not proceed with the work until unsatisfactory conditions have been corrected.

3.2 INSTALLATION

1. Furnish and install factory assembled Indoor units of the types, sizes, capacities, and arrangements indicated on the drawings and specified herein.
2. Install in accordance with the manufacturer instructions using tools approved by manufacturer.
3. Coordinate installations of the units with the architectural and electrical works
4. Supply units fully charged with refrigerant and filled with oil
5. Units shall be delivered along with refnet joints & refnet headers to facilitate installation & increase the system reliability.
6. Pipes to be connected using non weld connectors "Lokring" to sizes 1 1/8 and welding above that size. Pipe Ends should be covered by a Lokring Stopper in case indoor will be installed at later stage.

3.3 INSTALLATION

1. The installation company shall be Approved Manufacture Installers, whose installation engineers shall have attended the relevant VRF Manufacture equipment courses. Proof of compliance may be requested before approving submittal. Approval is given by a Manufacture Distributor. The
2. tendering contractor must state on his tender return submission the name of the specialist
3. Manufacture approved sub-contractor to be employed to carry out the VRF installation.
4. The installation of all internal and external units, refrigerant pipe work, inter-connecting wiring, testing shall be carried out by the above stated approved Manufacture Installer.
5. The approved VRF Manufacture installer shall on his cost get a Manufacture Distributor's representative who should witness the commissioning of the VRF system and do final inspection prior to startup. Installer should provide the following for engineer and manufacturer representative:
 1. Record Pressure Test (Holding Pressure)
 2. As Built Drawings showing sizes and length of pipes per circuit.

3. Draw and Record Pipe Lengths and diameter in sketch as built per circuit.
 4. Submit calculations of additional refrigerate charges.
 5. Addressing of Fan Coils by group address
 6. Complete and issue Documents and Certificates to Consultant/Client.
6. Contractor on no extra cost shall receive the following from manufacturer representative, and present to engineer for record.
1. Service recordings for at least 2 hours of operation upon start up using service checker with a certified engineer having an experience of at least Five years in analysing checker recordings. And who has attended the relevant training course.
 2. Warranty after inspection and approval of installation works.
7. Should it deemed necessary full access should be afforded to the site during the installation of the VRF to allow a Manufacture Distributor's representative/engineer to verify that the installation methods being used comply and are fully in accordance with the Manufacture VRF Installation Instructions, requirement in order that the equipment warranties will not be invalidated.
8. Nominated Approved Manufacture Installers should have a certificate from Manufacture Distributor.

3.4 REFRIGERATION PIPEWORK

1. Supply, install, test and commission all interconnecting refrigeration pipe work between the outdoor unit and the connected indoor units with sizing and thickness as recommended by manufacturer. Non welding Lokring joints should be used in connecting sizes below 1 1/8 in most cases and Lokring Stopper should be used if Indoor is going to be installed in a later stage.
2. The pipe work installation, charging, testing and commissioning shall be carried out by registered refrigeration engineers, who shall be fully trained in the safe handling of refrigerants and trained in brazing techniques. Technicians should be trained for welding and installing VRF systems by a factory engineer and should be certified from manufacturer.
3. The installation shall be fully in accordance with British Standard BS EN378: 2000 Parts 2-3 and Manufacture's design and installation instructions listed in the VRF Installation Instructions.
4. All pipe work installations shall be carried out in refrigerant quality soft or half hard drawn pre insulated copper tubing to BS2871 Part 2: 1972 and complete with the appropriate Refnet headers and Refnet joints.
5. Longest possible lengths of pre insulated copper pipe shall be utilized to minimize the number of joints on site; appropriate refrigeration installation tools must be utilized to avoid the use of elbows. In case specific location requires welding, Oxygen free dry Nitrogen (OFN) must be used and blown during welding (no cold brazing is allowed) to avoid oxidation inside pipes. In case oxidation is found inside pipe due to not using Nitrogen replacement without welding, pre insulated copper pipes could be changes if requested by engineer and manufacturer.
6. Pipe work shall be properly and neatly fixed and supported at a minimum of 2 meter intervals and where possible should be run on galvanised cable tray. All

pipe work to be tagged with ID number (Condensing Unit ref) at 3 meter intervals.

7. Pipe supports shall not restrict expansion or contraction of the pipe and restraint must not be applied to Refnet joints or Headers. Every 15 meters in risers an expansion loop should be done in accordance to pre insulated copper piping installation works.
8. All pipe work (suction and liquid) to be insulated with slip on close cell electrometric pipe insulation (as manufactured by Armaflex or equal and approved), fire rated to Class "O" Building Regulations 1985, with a wall thickness of not less than 10mm in small sizes and 20 mm in large sizes. Insulation must be protected when exposed to atmosphere by special paint or covered by an enclosure or cladding.
9. All joints, after pressure and leak testing, are to be properly glued and or taped as to provide a complete seal to prevent any condensation, and shall be clearly marked for ease of identification.
10. After installation of pipe work, prior to connection to the condensing units, sealing of insulation joints and starting of equipment, pipe work should be pressure tested using oxygen free dry nitrogen as out lined below to 38 Bar (551 Psi), held for 24 hours and checked for leaks.

Step 1	Pressurize to 10.3 Bar (149 Psi)	3 minutes or longer	Discovery of major leaks
Step 2	Pressurize to 21.5 Bar (312 Psi)	5 minutes or longer	
Step 3	Pressurize to 38 Bar (551 Psi)	24 Hrs. minimum	Discovery of minor leaks

11. The system shall then be vacuumed/dehydrated to 0.2 torr (-755mmHg) using a 2-stage vacuum pump with non-return valve in less than 2 hours and then held at that setting for 1 hour (minimum) to ensure successful vacuum. If Vacuum was not reached in above timings, break vacuum with dry nitrogen up to +0.5 bar and repeat the vacuum process again. All of the above works shall be carried out before electrical connection is made to the fan coil units.
12. The additional refrigerant (HFC R410A) charge shall be calculated and weighed to accommodate the actual installed and measured length of pipe work all in accordance to manufacture recommendations and instructions listed in the VRF Installation Instructions.
13. The charging should be carried out with an appropriate charging station in the liquid phase and under supervision, no charging without a weighting scale is allowed and recorded additional charge should be recorded on each outdoor unit.

3.5 CONTROL WIRING

1. All control wiring is to be carried out in 2 core 0.75mm² - 1.25mm² PVC non screened CY flexible control cabling to BS6141 and BS6500 (To comply with CE Regulations 1995) colour coded and separately marked at 3 meter intervals for ease of identification and maintenance.
2. A cross wiring check function should be present to identify any connection errors in the system & give an obvious alert for it.

3.6 EQUIPMENT MAINTENANCE & WARRANTY

1. The sub-contractor shall supply all the specified equipment complete with one year's warranty on both materials and labor commencing on satisfactory hand-over of the complete system.

2. The sub-contractor shall include for a one-year maintenance contract on the complete installation, with guaranteed maximum 48-hour response time. The sub-contractor shall ensure that the warranty and maintenance contract he provides is underwritten and approved by Manufacture Distributor, and shall provide to the employer documentary evidence of the same.
3. The maintenance contract, which must be in place within three months of project completion, shall include for all works necessary to ensure that the three-year equipment warranty given by Manufacture is not invalidated, and shall provide documentary evidence to this effect.

END OF SECTION